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Shuttle Close-Out Photography

Intelligent Interactive Visual Database Management System

Annual Report

Dr. James Ragusa, P.I.
College of Business
Department of Management
University of Central Florida

Dr. Gary Orwig, Co.I.
College of Education
Instructional Systems Program
University of Central Florida

Mr. Gholam A. Shaykhian, Co.I.
College of Engineering
Dept. of Engineering Technology
University of Central Florida

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I. Introduction

This research activity began with a draft proposal that was part of the document A proposal to NASA/Kennedy Space Center for a research grant entitled 'Cooperative Agreement for Technology Development'. This composite proposal was submitted on April 5, 1989.

The initial proposal resulted in funding that was provided during the 1989 Summer Term for faculty to research, prepare and present final versions of their proposals. This funding was later extended in order to align the projects with the NASA funding cycle.

The first fully funded year of this research project began in December, 1989. Because this is the first annual report on the project, it will cover activities that occurred both during the preliminary funding and during the first fiscal year.

Research Faculty

Dr. James Ragusa

Dr. James Ragusa is an Associate Professor in UCF's College of Business. Dr. Ragusa serves as Principal Investigator for the NASA/UCF Intelligent Interactive Visual DBMS Project. Prior to joining UCF in January 1987, Dr. Ragusa was employed by NASA's John F. Kennedy Space Center for a period of 23 years. While assigned to the Director of Cargo Operations, Dr. Ragusa was responsible for Artificial Intelligence (experts systems) project activities for payload processing. In addition to overall project and research responsibilities, Dr. Ragusa teaches graduate and undergraduate (honors) expert systems courses. Dr. Ragusa has written extensively and is Manager for the College of Business Intelligent Multimedia Applications Laboratory (IMAL).

Dr. Gary Orwig

Dr. Orwig is an Associate Professor of Instructional Systems in the College of Education at UCF. Dr. Orwig is highly experienced in multimedia database management systems and serves as a frequent consultant to business and industry in system integration of new hardware and software technologies related to computer driven multimedia applications. As a Co-investigator in this project, Dr. Orwig conducts research and provides advice on the procurement of multimedia systems. He conducts research into image oriented expert systems, and serves as a proposal and report writer for the project team.

Mr. Gholan A. Shakhyian

Mr. Shakhyian is an Assistant Professor of Engineering Technology in UCF's College of Engineering. As a Co-investigator he is responsible for object oriented programming, the development of database management systems, and system integration with NASA's SPDMS II. In addition to his faculty and research responsibilities, Ali is a consultant for several NASA contractors.

Research Associates

David Blacklock completed one career as a police sergeant with the Orlando Police Department with his retirement in January of 1990. David began work as a Research Associate in April 1990. He received a Bachelor of Arts from Rollins College in 1973 and a Masters of Business Administration from the University of Central Florida in 1989. He completed the UCF College of Business expert systems course MAN 6938 in the Fall 1988 semester. David has been charged with the following long term assignments in the IMAL: (1) take the lead for expertise in optical technologies, (2) maintain expertise in retrieval technologies, (3) develop proficiency in presentation graphics, (4) develop neural network expertise, and (5) research literature for items of interest to IMAL activities.

Todd Schieffelin graduated from the University of Central Florida with a MBA and undergraduate degrees in Finance and Economics in 1989, 1988 and 1987, respectively. While enrolled in graduate school he worked part-time as a computer consultant specializing in financial analysis via spreadsheets and presentation graphics. While in the MBA program at UCF he enrolled in Dr. Ragusa's expert system class. In this class he met fellow researchers Ann Baron and Dave Blacklock. At the conclusion of the course he worked as an independent study student with Ann Baron, Mike Vine and Dr. Ragusa on the IST grant to interface expert systems technology with laser optics. The result was the "The Chateaux Connoisseur". While not working on the NASA grant, Todd works as a management consultant for a regional insurance company.

Russ Wielgos is currently a graduate student in Business Administration. His undergraduate degree is in computer science from Northern Illinois University, and he has worked as a computer programmer/systems analyst for several years at Arthur Andersen & Co. Russ has been involved in a number of the NASA grant activities, and is currently in charge of the IMAL expert system development and research.

Description of Research Objectives

The original research objectives for the first year of this project follow:

1. Conduct a systems analysis of a large scale traditional image processing operation.
2. Collect data on critical human and performance factors in the areas of image creation, processing, storage, and retrieval. Sample factors include but are not limited to: A) maximum data gathering equipment size allowed, B) resolution required, C) contrast, shading, and color factors required, D) indexed fields - current and future needs, E) desired storage and retrieval strategies, including nonverbal (image based) techniques, F) maximum acceptable retrieval time.
3. Validate the attributes identified above through the creation and testing of analog prototyping models.

The following operational objectives have evolved over the first year of the project.

1. Determine the technological feasibility of intelligent interfacing between AI knowledge-bases information systems and mass storage laser-optical devices for purposes of visual data collection, storage, search and retrieval, and transmission.
2. Recommend improvements to the existing SPC close-out and problems statusing photographic management systems.
3. Ensure that development technology is compatible with SPDMS II and supports LSOC's goal of paperless management of data recording, retrieval, and analysis.
4. Identify other application which could benefit from the resultant technology.
5. Business, Industry Visits, and Workshops

II. Activities and Accomplishments

1. KSC Visits, Contacts

There have been numerous visits to KSC over the contract period. They fall into various categories including: (1) establishing NASA and LSOC technical contacts; (2) acquiring technical and administrative information; (3) briefing NASA, LSOC, and other KSC management representatives. More specifically, project team members (faculty and students) traveled to KSC to work with LSOC shuttle closeout and SPDMS II processing representatives, coordinating with NASA and TGS photo/engineering personnel, and briefing KSC and NASA-Hq. personnel. In addition, various student groups worked in support of this cooperative agreement interacted with various organizational members.

The primary project contacts for this cooperative agreement:

LSOC	John Seaman (Quality Operations) Kevin Paule (Quality Data Center)
Analex	Gene Cain (LSOC support)
NASA	Astrid Heard (Advanced Projects) Tom Davis (Advanced Projects) Nancy Pope (Photo Support) George Dutt (Photo Support)
TGS	Sherline Turbyville Cathy King

The visits to KSC were critical to the task analysis that allowed project team members to chart the entire shuttle close-out photography collection, processing, classification, storage, and retrieval sequence.

2. Survey

During the fall of 1990 a telephone survey was conducted of selected NASA employees and related contractor employees. The intent of the survey was to establish an initial base of knowledge regarding the end users and uses of the photographs. The results of the survey are tabulated in Appendix A, while comments that are related to specific questions are reported in Appendix B.

In summary, most of those who were interviewed indicated that they presently work with Shuttle Close-out photographs in the 8 x 10 color format. Over 75% need to retrieve photographs at least once a month after they have been stored at their facilities. Almost all felt they could not get enough information from black and white photographs, and almost all felt the resolution

provided by the enlargements that they work with is sufficient for most situations. All who were interviewed were positive toward an electronic system if it could provide the same image quality now provided through the enlargements.

3. Business, Industry Visits

Team members have been tracking the development of Digital Video Interactive (DVI) technology by Intel and IBM. Although the motion aspects of this emerging technology have drawn the most public attention, the high resolution, highly compressed still image storage capability of this technology is of particular interest to this research project. As a result, Dr. Orwig attended a DVI Developers workshop that was sponsored by Intel at the 1990 Orlando SALT conference in February. The workshop provided a wealth of information on the topic. Some of the most important information related to planned releases of improved hardware and software.

Dave Blacklock attended the Optical Information Systems Conference in September of 1990. It was targeted toward vendors, users, system integrators, and value added resellers of optical equipment. The conference emphasized the conversion of paper documentation to optical storage and retrieval techniques. Compression standards, object oriented interfaces, remote access to images, and optical storage increasing capacities were discussed.

There have been several opportunities for the UCF project team to demonstrate expert systems/laser-optical technologies to interested workshop and conference attendees. They include:

- The Eleventh International Joint Conference on Artificial Intelligence (IJCAI), August 20-25, 1989, Detroit, Michigan.

- The Florida AI Research Symposium (FLAIRS), April 3-6, 1990, Cocoa Beach, Florida.

- Interservice, Industry Training Systems Conference (IITSC), October, 1990, Orlando, Florida

4. Intelligent Multimedia Applications Laboratory

A new facility, the Intelligent Multimedia Applications Laboratory (IMAL), has been established in the College of Business. The primary purposes are to provide an environment for this NASA research project and for the development of applications using artificial intelligence technology and multimedia devices to solve a variety of business problems.

The IMAL Reference Library

The IMAL houses a growing research reference collection available - on a non-interference basis with on-going grant activities - to faculty, students, and others interested in researching AI and multimedia technologies.

The collection consists of the following:

1. AI Papers and Reports. Microfiche copies of academic papers and reports from Carnegie-Mellon, Stanford, MIT, and Yale that document early AI developments.

2. AI Journal Articles and Research Reports. There are currently more that 1200 AI references spanning the fields of management, MIS, production operations, training, personnel, accounting, finance, economics, and marketing.

3. Expert System Prototype Applications. More that 170 reports have been produced that describe business related knowledge-based system prototypes created by UCF graduate students and undergraduate students.

4. Book Collection. Over 100 books covering AI, knowledge-based systems, AI programming languages, database design, presentation graphics, and multimedia have been cataloged.

5. Conference Proceedings. Important conference proceedings on AI, multimedia, and related subjects are included.

6. Periodicals and Magazines. AI, multimedia, and computer related magazines and periodicals have been collected.

7. Video tapes. Twenty-eight (28) video tapes which describe AI, expert systems, and the process of knowledge engineering are housed in the collection.

Computer aided searching of data records is extremely easy to do. The user is presented a fill in the blank type screen. Depending upon which blanks are filled in, the appropriate search will take place. The reference library databases contain abstracts (usually 100 - 450 words) of each article, book, etc. which the user can search.

The reference library also allows for updates from student assignments. This feature allows faculty to hand out a version of the reference library on a diskette to students in selected classes so that they can enter reference information from assignments directly onto the diskette. Once the assignment is completed the information is appended to the main database.

IMAL Hardware and Software Inventory

Hardware

Zenith Laptop ZTV-3040-MO	$ 4,100
Intel 386 Model PSYP302250DOX	$ 7,543
2 - Zenith Model ZCM-1492	$ 1,118
Sony Trinitron DVM-1390	$ 483
Sony Trinitron DVM-1910	$ 860
Pioneer Laservision Player LD-V8000	$ 2,443
Panasonic TQ-3031F	$18,995
JVC Camera Head TK-870U	$ 2,140
Bencher Copy Mate II	$ 200
4 - Optical Discs	$ 1,280

Software

Dr. Halo	$ 10
VP/Expert SQL	$ 348
Level5 Object	$ 500
1st Class HT	$ 2,505
EXSYS-EL	$ 129
Neural Works Explorer	$ 199
Olmsted and Watkins OWL Neural Networks Library	$ 150
Microsoft Quick C	$ 24
Turbo C++	$ 85
Windows 3.0	$ 115
Owl Guide	$ 108

IMAL Usage Records

On August 29, 1990 a visitor log was began in the IMAL to capture the date, name, organization, and phone number of visitors to the IMAL. As of December 7, 1990, there were 150 visits recorded. There were seventy-three (73) business days of the IMAL. Therefore, there have been an average of two visitors the IMAL per business day.

5. Student Involvement

The research faculty and associates of this cooperative agreement have been supported by the graduate students from Dr. Ragusa's Expert Systems classes and graduate/undergraduate students from the Colleges of Business, Engineering, and Education. The following are the expert system prototype developments that have utilized student talents:

The Chateaux Connoisseur (PC Easy Version)

The original version of the Chateaux Connoisseur was developed under a grant from the Institute for Simulation and Training.

This project represented one of the first efforts to link expert systems to interactive video devices. The video disc that was used as a visual database for the project was a commercial product titled "Salamandre, Chateaux of the Loire." This demo program was expanded to retrieve parameter values from a single database file. This represented the utilization of database retrieval techniques by an expert system. The effort revealed a limited ability of PC Easy to access information from a standard .dbf file. Specifically, PC Easy can only find exact matches. There are no provisions for character string matches or case insensitivity.

The Chateaux Connoisseur (Clipper Version)

The next version of the original demo program was written in Clipper. This represented an opposing approach to that of using a shell program. The Clipper version showed the almost limitless possibilities of using a language, but also the drawbacks of having to start from scratch. First, the development time was increased three-fold. This dealt primarily with building the user interface or menu system. Second, the addition of more "rules" is not as simple of a process as compared to the shell programs. Although the Clipper version contains If - Then statements, clever programming is needed to ensure the "rules" fire in the right order, a process not needed in shell development.

On the plus side, Clipper allowed for much greater flexibility and speed. The flexibility allowed a much more attractive interface with colorful windows. The speed of the Clipper was roughly tenfold. This allowed the menus to change instantaneously after a response was selected, a greatly added benefit.

The Chateaux Connoisseur (Guide Version)

The Guide version represents a move into the object-oriented world. Guide is an authoring system that runs under Windows 3.0. The Guide version was not successfully completed. A snag arose when researchers tried to step forward and step backward within a predetermined range. A remedy to the problem would be to write a laser disc driver that would be Windows and Guide compatible.

The effort resulted in several telephone conversations with Owl International, makers of Guide. Most of the conversations were of little or no help. In fact this project appears to be the first to interface their product with a laser disc player. The Guide version did have a distinct advantage over the other versions -- the hypertext interface. This allowed the user to move quickly within the information in a format he/she chose.

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The Generic Database Program

The generic database program was developed replace the need for Ashton Tate's dBase III. The generic database program allows a user to create a database file from scratch. Additionally, the program allows a user to edit, add and delete fields from an existing database. Further, a provision was designed to add, edit and delete records to the database. The thought behind the program was to allow a user to create a database file and design an expert system front end to classify (populate) and retrieve (search) data.

The code for generating all the panels (screen menus) is developed in Clipper database language. In addition, the communications between the expert shell and the laser disc are routed through the Clipper codes.

The player and/or recorder part of the laser disc is controlled by the code written in C++ language. The CPU and the analog laser disc are connected via a serial connection (standard RS-232). The laser disc receives a frame number from the CPU for display purpose and displays the image located at that frame number. The collected visual data and the frame number read by C++ are appended to the database and the image is stored on the laser disc.

The Database - C Driver (Pioneer Disc Version)

The Pioneer version of the Database - C Driver allows a user to search a database and to control the Pioneer laser disc player from the DOS prompt. The Database - C Driver will conduct a search of up to ten fields of a named database. If a match is found it will display the appropriate images. A special feature of this driver is that it allows for the stepping forward and backward through matching records. The thought behind this driver is that it allows one to write his or her own searches. This allows one to use indexes and it addresses the previous problem of limited character string search capabilities. A major problem with this driver is that it requires 160K. This presents a problem when trying to use it with many of the shell programs.

The Database - C Driver (Panasonic Version)

The Panasonic version is essentially the same as the Pioneer version. The only difference is that it controls the Panasonic Optical Disc Recorder/Player.

NAPSAC and PRAISE

During the Fall semester of 1989, two student groups from Dr. Ragusa's Expert Systems class visited the Kennedy Space Center, TGS and Lockheed to gather necessary information for building

both photo classifier and photo retrieval expert system prototypes. These expert systems would address the problem of processing and storing the multitude of space shuttle pictures taken for each launch.

Following various knowledge engineering sessions, both student groups built their respective prototypes, which they called NAPSAC (NASA Photo System to Aid in Classification) and PRAISE (Photo Retrieval And Intelligent System Expert). A demonstration of these prototypes, along with an executive summary report, were presented to NASA, TGS and Lockheed officials.

These original prototypes were built using the Texas Instruments' PC EASY product and, although the shell proved quite capable of handling the requirements of the two applications, the project groups noticed many drawbacks in using this particular software package. These drawbacks prompted a search for a more capable shell for use with these two applications. The resulting research consisted of new product education, as well as the actual cloning of the original two applications in various other expert system shell software products. The hands-on results of this continuing research are provided in Appendix C.

Expert System Selection Advisor

Because a large number of expert system shells have been examined in relation to this project, an expert system is under development that will help advise a user on the appropriate expert system shell to user for any specific application. This shell will capitalize upon the experiences of the faculty and students who have had direct experience with various shells.

III. Budget Projected vs. Real Summary (Nov 1, 1989 to Dec 21, 1990)

	Planned	Actual
Faculty Salaries	$59,253	$60,493
Students/Associates (OPS)	$30,520	$40,746
Expenses	$18,500	$12,046
Equipment(OCO)	$43,356	$40,296
Overhead	$53,054	$53,184
Totals	$204,683	$207,062

As can be seen above, the planned vs. actual expenditures are very close to each other. Specifically, very little variance took place in faculty salaries. The greatest variance was in the category of student/research associate expenses. The difference of $10,000+ was absorbed from expenses and equipment. It is felt that these increased expenses were in the best interest of the long term goals of the project.

IV. Preview of Next Year

The plans for the 1991 project year are directed toward a transition from analog image storage and retrieval toward digital image storage and retrieval. The use of expert systems to drive digital image database classification, storage, and retrieval systems will be examined. Due to the high resolutions required for the digital images, it is anticipated that image compression /decompression software will be required. Finally, it is anticipated that interface drivers will need to be written to link the expert systems with the image capture, compression, and decompression software.

Elements of interest in this research relate to file sizes, compression ratios, quality of images once they are decompressed, and retrieval/decompression access times. While some performance information is available from individual vendors, virtually no performance data has been reported for integrated systems. This systems integration research will help to determine the parameters under which digital image storage and retrieval systems might be implemented.

In relation to this expansion into digital technology, it is anticipated that several purchases will be required. In particular, a color scanner, a video frame grabber, a 1280 x 1024 pixel display system, and image processing software have been specified.

While DVI and competing technologies will continue to be tracked, they have been removed from the purchase list for the short term. At the present these technologies are still emerging, and as a result there are few commercial software packages available that will serve the needs of this research.

Most of the research of the previous year will continue. In particular, additional expert system shells will be evaluated. Also, the Level5 Object software will be examined in greater detail to determine its strengths and weaknesses in accessing image databases. Interfacing techniques will continue through object oriented programming. In particular, C++ has been chosen as the high level language for the device drivers and other interfaces that will be required.

Finally, research will continue into intelligent object oriented database management systems. Specifications for several commercial products now indicate a combination of the expert system and database management functions into one software system. Because these products are in an early stage of product evolution, there exists a need to determine how well they can perform in prototype applications.

V. Appendices

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Appendix A

Shuttle Close-Out Photography
End User Survey

UCF - NASA Project
Shuttle Close-Out Photography
End-User Survey

Survey Summary

A. User Profile

1. Employer's Name LSO, TU-MSD, USBI, Morton Thiokol, MMC, USBI

2. Location (City, State) KSC, Brigham City, New Orleans, Huntsville

3. Job Title Almost all engineering, management

4. Very briefly state your job responsibilities as they relate to the shuttle.
   Quality Control, Engineering Review, Public Relations

B. Current / Potential Need for Closeout Photographs

5. Do you currently make use of Shuttle Close-Out photographs?

   YES 100% NO _____

   If NO, go to Question 13
   If YES, please answer through number 12.

6. What size of prints do you prefer to use? (Check one or more.)

   8% Contact Sheets
   92% 8 X 10 Prints (23% use both)
   _____ Prints larger than 8 X 10
   _____ Other (Briefly describe)

7. Are the prints delivered soon enough for them to be of maximum value to you?

   YES 69% NO 31%

8. How are the prints stored and accessed at your facility?

   _____ We throw them out when we are done with them.
   92% We file them in cabinets.
   _____ We have a computer-based logging system.
   8% Other (Briefly explain) (Boxes)

9. How often do you need to retrieve or replace a photograph that has been stored or thrown out?

31% More than once a week
15% Once a week
31% Once a month
23% Once a year

10. Could you get by with black and white pictures?

YES 8% NO 92%

11. Is the **quality** of the color of a photograph important to your use of it?

YES 77% NO 23%

12. Do most of the close-out photographs contain sufficient image resolution? (Can you see what you need to see?)

8% No, I need more image resolution (clarity).
92% Yes, they have sufficient image resolution.
_____ Yes, in fact, they have **more** resolution than I need

13. If color and detail were similar to what you use now, would you consider working with an on-line (computer) image retrieval and delivery system?

_____ No Way
92% Sure
8% Maybe, if it would do the following:

(No specific comment regarding the "maybe")

The following are questions for those who don't currently use Shuttle Close-Out photographs.

14. I don't currently use these photographs because:

_____ They haven't been made available to me.
_____ They aren't needed for what I do.
_____ Other (Please Explain)

15. If an on-line (computer) image retrieval system were available to you for these photographs, ...

_____ I wouldn't need it.
_____ It might be useful in the following way(s) ... _____

_____

Appendix B

Shuttle Close-Out Photography
NASA Survey Comments

NASA Survey Comments

5. Do you currently make use of Shuttle Close-Out photographs?

(YES)

For flight readiness reviews and mandatory review requirements

For ET/SRB groups (10 engineers review each photo)
ET approx. 400 photos per mission
SRB approx. 400 photos per mission

For Q.A. function, historical documentation, anomaly investigations

6. What size prints do you prefer to use?

(Contact Sheets)

Too small, but sometimes used for identification purposes

Too small, not enough resolution when used with a magnifier

(8 x 10 Prints)

Expensive, use only when necessary

7. Are the prints delivered soon enough ...?

(YES)

Normally takes 2.5 to 3 weeks
If emergency, can sometimes get them the next day

Usually available in 2 days

Usually available in one week

We don't usually need them right away

(NO)

14 - 15 days are normal

Usually two week turnaround
Would prefer normal next day turnaround
A good reason for video would be to see if the pictures are ok initially

8. How are the prints stored and accessed ...?

(We file them in cabinets)

Manual storage by photo number
Keep photos for 1 year, then put into long term storage
Arranged by area (takes about 10 minutes to find)

Filed by topic, procedure, and number

Filed by subject, area, and date

Filed by topic

Filed by flight

Filed by categories
Filed by engineers
Organization
ET: 50 groups
SRB: 25 - 30 groups
Would like to be able to review based upon date/subjects rather than memory
Photos older that 10-12 vehicles now in long term storage

Filed by mission/subject, but with no consistency

Filed by launch

9. How often do you need to retrieve or replace a photograph that has been stored or thrown out?

NOTE: I think this question was interpreted two ways. It appears that some of those who didn't check one of the options or who picked "once a year" were thinking "How often do you need to access any ONE PARTICULAR photograph?" while others understood the question to mean "How often do you need to retrieve ANY photograph?"

(More than once a week)

Approximately 200 retrievals a year

We must make daily retrievals

(Other Comments)

On occasion

Variable

Rarely

Once a year or less. There are some photos that we may not ever need to retrieve.

10. Could you get by with black and white pictures?

(NO)

Color very important, Could not do without. Eg. Bonding, primer

Looking for discoloration
Some tags/pieces are color coded. Eg. Red - Remove for flight

Color absolutely essential

11. Is the quality of a color photograph important ...?

(YES)

Overall, photographers do a good job of maintaining quality

Operator skills are important

(NO)

Shade variations not always critical

Shade of color not critical, can mentally adjust

12. Do most close-out photos contain sufficient image resolution?

(YES)

Depends on lighting/aperture. Present lighting a problem

In 80% of the cases, ok. Would like more resolution

contact prints not good enough

Ok in most cases, but sometimes not enough

OK, but cannot be less and still be acceptable

13. Would you consider on-line ... ?

(YES)

Need hard-copy, slides, color output

Would love it for review

Must have hard copy 50% of the time

Want terminal for faster retrieval

Would be good for static storage

Appendix C

Comparison of Expert System Shell Software

COMPARISON OF EXPERT SYSTEM SHELL SOFTWARE

Over the past year, the NASA Photo Classifier (NAPSAC) and Retriever (PRAISE) expert systems have evolved from a pair of large, slow moving student projects into two more efficient expert system prototypes. This evolution was made possible through explorations with several expert system shells. The following is a summary of the advantages and disadvantages of various expert system products in relation to these two applications.

PCEASY Advantages

- The use of color in the various title, question and conclusion screens make the system more appealing to the eye and quite user-friendly.

- The length of the inputed photo descriptions are only limited by the size of the data base field it will be written to.

- The length of the various user Help screens is limitless.

- The finished knowledge base can be converted to 'C' language to increase runtime speed.

- All application functions, such as Help screens and description inputs, are internal to the PC Easy software. The only external interface needed is with dbase.

- There is no real limitation on parameter names and lengths.

- Conclusions can be presented to the user on one screen.

PC EASY Disadvantages

- The unfinished application has already reached its memory constraints.

- The runtime and development speed are quite slow.

- The initialization questions, such as date of photo, photographer, KSC number, etc., each needs to be handled using one question and response per screen (a total of 10 screens).

- PC EASY has an inability to hold large rules without impeding response and development time.

- There is an absence of on-screen validation techniques.

- The shell requires the application to send a value for each data base field in each record, regardless of whether the field contains a value or null.

- PC EASY returns very non-descriptive error messages.

KAPPA Advantages

- Initialization prompts, such as date of photo, photographer, KSC number, can all be inputed using one input screen.
- Rules can be formed using menu screens and/or written text-type screens.
- The shell runs under the user-friendly Microsoft Windows package.
- The shell gives the application the user of object-oriented programming. At the present time, this feature is not crucial to the application.

KAPPA Disadvantages

- The system response time is quite slow.
- There is a limit of 190 characters on the user help screens.
- Input description fields are limited to 31 characters.
- When a rule is not satisfied, the system will ask the user for the value of the goal. This is not always required.
- Conclusion screens cannot easily be shown using one screen.
- No color choice of text is available.
- There may be a bug in Kappa Version 1.0, due to the fact that some rules are not fired upon correct answering of the questions. Identical inputing of these fields may lead to a different result (i.e. correct firing of the rules).
- The purchase of Microsoft Windows is an extra cost.
- The Kappa manual is not very well written or complete and fails to describe the definition of object-oriented programming very well.

1st-Class Hypertext Advantages

- Rules can be induced by filling in a spreadsheet-type form.
- Rules can be presented in an easy to read structure tree.
- The shell has the capability of using hypertext for help and conclusion screens.

- The numeric initialization fields, such as date of photo, roll number, and frame number, can be input on one input form.

- Color may be added to textual questions and help screens.

- Conclusions can be presented to the user on one screen.

1st-Class Hypertext Disadvantages

- There is a database limit of 65,000 records.

- Large applications are difficult to put into example form. These examples are used to induce rules.

- There is no capability for textual input, such as the photographer and photo description.

- Parameter names are limited to approximately 8 characters. This causes multiple choice answers to be abbreviated to the user.

- There is no validation of numeric input ranges.

- No confidence levels are allowed on rules. This feature was not crucial to this application.

- The length of a rule is limited to approximately 840 lines. This disadvantage can be solved by linking various rules (i.e. knowledge bases), but this linking will slow down consultation time.

- The shell only allows for 32 factors (parameters) and 128 values for each factor.

EXSYS EL Advantages

- Ability to create own screens and windows

- Input maximum is 1,000 characters

- Ability to quickly rerun the consultation with new input choices

- Three types of confidence level use

- Easy to Learn and Use (possibly easier than PC Easy)

- Written in C language making it quicker than PC Easy

- Has rules and text in two different files. This also will aid speed.

- DBASE and Lotus Interface
- External Linkage possible
- Ability to generate report with Report Generator
- Complete, easy to read manual

EXSYS EL Disadvantages

- No Form creating capability
- No mouse capability
- Creating a knowledge base requires manipulating around a number of menu screens. No rule text editor is available. EXSYS Professional has the capability to take rules from Word Perfect and compile them into KB files.
- No hypertext feature for help screens. This is available in EXSYS Professional.
- Limited number of runtime installations
- Knowledge base name must be known in order to access it. There is no menu containing KB names to choose from.

VP-EXPERT/SQL Advantages

- Ability to create input forms for users to enter data
- Mouse capability
- Provides a runtime and development mode
- Good search functions
- Fast consultation time
- Allows developer to type rules into a textual editor
- Very easy to learn and use
- Capability to induce rules from tables
- Contains hypertext capabilities (not tested by author)
- Dbase, SQL and LOTUS interfaces
- Ability for external linkage
- Contains a graphics text tree for tracing knowledge flow

- The created NAPSAC and PRAISE knowledge bases take up a tenth of the space as they do in PC Easy

VP-EXPERT/SQL Disadvantages

- Input length is limited to 30 characters
- Field names are limited to 20 characters
- No user help is provided with completed expert systems
- Unable to find any graphics capabilities
- Programming of the input form can get quite complicated
- No input validation
- The user needs a mouse AND the Return key to manipulate around the input form

At the present time, it has been determined that the most suitable expert system shells for the two prototype applications (NAPSAC and PRAISE) to be VP-Expert/SQL and 1st-Class Hypertext, in that order. The original applications have been recreated and expanded upon using VP-Expert/SQL, The results are much quicker applications, using only one-tenth of the memory space as PC-EASY. The improved prototypes are also more efficient and user friendly.

During the second year of the project, a review will be conducted of various object-oriented expert systems shells, such as Level 5 Object and KBMS, to see what value they may lend to the NAPSAC and PRAISE applications. The review of non-object-oriented shells will also be continued. This hands-on approach, should allow the faculty and students to become better informed on what these various shells have to offer.

Appendix D

Software Interfaces

Software Interfaces

Laser Disc Recorder/Player Drivers

The general purpose of the following programs is to provide a user-friendly interface between an artificial intelligence expert system and a laserdisc recorder/player through the use of DBase files and C++ programming.

There are three sub-purposes as follows: to provide a user interface, to provide a DBase file interface, and to provide communications between a laserdisc Recorder/Player and an IBM PC.

These sub-purposes are supported by three sets of programs. The programs will be discussed in terms of the sets to which they belong.

Functional Descriptions of Programs

User Interface

The user interface programs are listed below. All of the programs are functional and complete. However, all of the programs could be enhanced to take advantage of the Windows environment.

BUNCH. H
COMMON.H
DISPLAY.H
GPOPUP.H
HEADER.H
LIST.H
MNUM.H
CAL.H
EVERT.H
GTEXT.H
MANAGER.H
MOUSE.H
OBJECT.H
PEN.H

DBase III Interface

Only one program supports the DBase III interface - DBASE.H. It is considered incomplete. It should have the following enhancements: (1) DBase searching for multiple indexes and (2) the present limit of 50 records should be eliminated using dynamic memory management.

Communications

Only one program supports the Communication interface - SERPORT.H. It is considered incomplete. It should have the following enhancements: Detailed Serial Port error report.

Major Functions of Programs

User Interface

The major function of each program is as follows:

BUNCH. H	-	Generates the windows environment.
COMMON.H	-	Provide a collection of all the user interface variables.
DISPLAY.H	-	Display the current text value
GPOPUP.H	-	Provides a pop-up Window.
HEADER.H	-	Provides a structured data type.
LIST.H	-	Lists the data structure.
MNUM.H	-	Generates window for search by number.
CAL.H	-	Generates a menu window.
EVERT.H	-	Provides a window data type.
GTEXT.H	-	Provides a text input/output function in a graphics environment.
MANAGER.H	-	Manages window functions.
MOUSE.H	-	Supports the mouse.
OBJECT.H	-	Provides a window object function.
PEN.H	-	Provides a set of primitive graphic functions such as a square, circle, and a line.

DBase III Interface

DBASE.H has the function of searching picture information from the DBase files.

Communications

SERPORT.H has the function of setting communication modes and sending or receiving commands between the laserdisc recorder/player and the computer.

Compiling Information

Project file is used to generate a compiled program. Project program contains a set of files which include all source codes. The file extension of project file is .prj.

Disk.prj - generate a integrated program.

Laser.prj - generate a Pioneer interface program.
New.prj - generate a Panasonic interface program.

Disk.prj

BUNCH.CPP: Class Bunch allows the organization of Panes into any type of grouping desired. Bunch is a subclass of Pane. Bunch has a subclss, Manager.

Header Filels: BUNCH.H
COMMON.H

COMMON.CPP: Collection of commonly used functions and macro definitions

Header Files: COMMON.H

DISPLAY.CPP: Display depicts the window where the current value is display. As a subclass of Pane Display inherits methods and data objects from Pane and some methods from Bunch. The Display uses its constructor to clear the display and setup the Pens to paint the display. Class Display has seven public methods which have been redefined in this area class to meet Display need.

Header FIles: BUNCH.H
PANE.H

GPOPUP.CPP

HEADER.CPP

LIST.CPP: Class List performs the role of a general list manager and a list iterator. Class List consists of three class: l_node, List, and ListIterator. Class l_node is a linked list node and used by the general data structure classes, List.

Header FIles: List.h

MNUM.CPP

CAL.CPP

EVENT.CPP: Class Event performs a housekeeping job while working in conjunction with class Manager and Pane. Class Event records the type of mouse that has occurred.

Header Files: Event.h
Mouse.h

GTEXT.CPP

MANAGER.CPP: Class Manager performs the task of general management for the graphical control interface environment. To be displayed on the screen, a pane must be inserted ether directly or indirectly into Manager. Class Manager is a subclass of Bunch.

HeadFiles: MANAGE.H

MOUSE.CPP: Mouse Function implementation.

HeadFiles: Pen.h

OBJECT.CPP Objects on the screen like icons, menu selections, and other graphics figures can be put on a list and selected using the mouse. Each object has a function associated with it that is executed when the object is selected.

HeadFiles: <alloc.h>
<graphics.h>
<conio.h>
"mouse.h"
"object.h"

PEN.CPP: Class Pen is designed to control the pen status and movements on the screen, such as color, position, or mode.

HeadFiles: "Pen.h"
"Pane.h"
<Graphics.h>

PANE.CPP: Class Pane provides a restricted area for Pen to operate. Pen is allowed accesses to Pane's private data and member functions to draw icons or write text by declaring.

HeadFIles: "Pen.h"
"Pane.h"
<Graphics.h>

SERIAL PORT FUNCTION

The serial port library has several functions used to facilitate IBM PC serial port. Using these function, user easily create the customized laser disk control commands. These functions will work on Pioneer and Panasonic laser disk player. These serial port functions allow you to:

1. Initialize communication mode.
   - Communication port
   - Baud Rate
   - Parity
   - Character bit
   - Stop bit
2. Send character or string to disk player.
3. Receive character or string form disk player.
4. Contains Panasonic laser disk command.

Function Description

```
Name:     serial(int, char*, unsigned char)
Header:   SERPORT.H
Type:     class
Purpose:    contains a port initialization function.
Parameters:  port number( 0: for com1, 1: for com2)
             port name : any string
             initialization code: Baud_rate || Stop_bit ||
                                  Data_Bits
```

* Note: See Serport.H for more detailed parameter options

```
Name:    send(char*)
Header:   SERPORT.H
Type:    public
Purpose: send a character string to port
Parameters: character
Return: None

Name:    Receive(char*)
Header:   SERPORT.H
Type:    public
Purpose: receive a character string from port
Parameters: character
Return: None
```

Panasonic Command

```
friend void fwd_play();
   Purpose: forward play command
   Parameters: None
   Return:     None

friend void rev_play();
   Purpose: backward play command
```

```
   Parameters: None
   Return:     None

friend void fwd_step();
   Purpose: forward step command
   Parameters: None
   Return:     None

friend void rev_step();
   Purpose: backward play command
   Parameters: None
   Return:     None

friend void fwd_scan();
   Purpose: forward scan command
   Parameters: None
   Return:     None

friend void rev_scan();
   Purpose: backward scan command
   Parameters: None
   Return:     None

friend clear_command();
   Purpose: clear command buffer
   Parameters: None
   Return:     None

friend * read_frame();
   Purpose: read frame number from laser disk player
   Parameters: None
   Return:     None

void command_type0(char cmd[2]);
void command_type1(char cmd[2], char num[]);
void command_type2(char cmd[2], char num1[], char num2[]);
   Purpose: create Panasonic control commands as shown in manual,
            page 57-58.
```

Mouse Functions.

The mouse library has several functions used to facilitate Microsoft compatible mice. These functions will work on Microsoft mice or other mice using a Microsoft compatible driver. These mouse functions allow you to:

1. Initialize mouse/determine if mouse exists.
2. Get the status of button presses/releases.
3. Hide/reveal the mouse cursor.
4. Get/set the mouse cursor position.
5. Select type of mouse cursor (hardware or software).
6. Adjust the mouse sensitivity (speed).
7. Get information on direction of mouse movement.
8. Establish horizontal/vertical boundaries of mouse

movement.

Pen Functions

Class Pen has the following private data to indicate its status:

. mode :	mode of setfillstyle
. linetype:	line type for graphic function(see Turbo C++ graphic library)
. linepattern:	line pattern for graphic function(see Turbo C++ graphic library)
. thickness:	line thickness for graphic function(see Turbo C++ graphic library)
. color:	graphic color(see Turbo C++ graphic library for the number of color information)
. x, y:	position of the graphic components

Pen works closely with class Pand. Using its constructor and several member functions to work Pane, Pen can be call to perform:

Name: SetLinePattern(int, unsigned, int)
Purpose: Set line pattern(line type, pattern, thickness)
Parameter: 1: line type
2: line pattern
3: line thickness
Return: None

*note: the line setting is based on turbo line drawing option.

SetMode(int)
Purpose: Set mode of private parameter with class
Parameter: 1: mode of fill pattern(see Turbo C++ Manual)
Return: None

MoveTo(Pane *, int, int)
Purpose: Set position of Text
Parameter: 1. Pane pointer
2. X position
3. Y position
Return: None

* This function is same with gotoxy function except Pane Pointer.

Text(Pane *, char *)
Purpose: print character string on the screen. The position can be set by MoveTo function.
Parameter: 1. Pane pointer
2. Charter String

```
     Return:    None

Line(Pane *, int, int, int, int)
     Purpose: draw line
     Parameter: 1. Pane Pointer
                2. starting x position
                3. startint y position
                4. ending x position
                5. ending y position
     Return:    None

Rect(Pane *, int, int, int, int)
     Purpose: draw rectangle
     Parameter: 1. Pane Pointer
                2. starting x position
                3. startint y position
                4. ending x position
                5. ending y position
     Return:    None

Rect(Pane *, int, int, int, int)
     Purpose: draw filled rectangle
     Parameter: 1. Pane Pointer
                2. starting x position
                3. startint y position
                4. ending x position
                5. ending y position
     Return:    None
```

Pane Functions

Class Pane has the following private data to indicate its status:

```
     xoff, yoff:  offset from lower left corner of screen
     xrel, yrel:  offset from lower left corner of parent bunch
     xmax, ymax:  Maximal local coordinates
     fg_box clipbox: pane's area on screen
```

```
Header Files:  <graphics.h>
               <stdio.h>
               "list.h"
               "event.h"
               "common.h"
               "gtext.h"
```

Pane works closely with class Pen. Using its constructor and several member functions to work Pen, Pane can be call to perform:

```
virtual void Configure();

virtual void Draw();
```

```
virtual void Handle(Event &);

int Inside(int, int);
```

Purpose: Set line pattern(line type, pattern, thickness)
Parameter: 1: line type
2: line pattern
3: line thickness
Return: None

*note: the line setting is based on turbo line drawing option.

Class PaneList has the following public function:

```
void Append(Pane *n) {List::Append((void *) n);}

void Insert(Pane *n) {List::Insert((void *)n); }

void Delete(Pane *n) {List::Delete((void *)n); }

void Replace(Pane *n, Pane *r) {List::Replace((void *)n, (void
```

Laserdisc to Computer Interface (Panasonic)
by Hoi Yoo, 9/25/90

This documentation describes a Panasonic laserdisc interface with an IBM PC. The interfacing can be achieved by a RS232 communication prototype controlled by a computer program. The program used is Turbo C++, by Borland International, Inc. Laser disk pictures are coded into a Dbase III file with a picture name, start frame number, end frame, and type of picture. This documentation only includes the technical specification of laserdisc communication.

This documentation for interfacing consists of three parts: connection, communication mode, and control commands.

Connection

There are two connections options. See Panasonic operating instructions in metal file cabinet. On page 50, Examples 1 and 2 show types 1 and 2. In the connection, we use type 1.

Communication Mode

See page 49 of the operating instructions for the "Communication mode set up". Changes to the written set up are as follows:

1.	Baud rate	2400 baud
2.	Character bit	8 bit
3.	Parity	no parity
4.	Stop bit	1
5.	Communication type	Type 1

6. XON/XOFF (have used XON, but does not matter; could be XOFF)

IBM PC communication port : serial port (can choice either port1 or prot2). However, have used port1.

Control Commands

See page 53 - 59 of operating manual for control commands.

Most important control command is the COMMAND FORMAT, page 53., no. 2. Every command must be followed by the command format. More detail is offered on page 56 - 59 for individual command types.

Control command to make a connection between the laserdisc and the computer is as follows:

See page 80, no. 5, for ON-LINE CONTROL COMMANDS. This command must come first with every communication to establish communication with the laserdisc.

Table 1, page 80, shows On-line modes. There are 16 options for modes. We use mode 0.

Appendix E

"Expert systems and imaging: NASA's start-up work in intelligent image management"

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Expert Systems and Imaging: NASA's Start-Up Work in Intelligent Image Management

James M. Ragusa and Gary W. Orwig

An ambitious, three-year cooperative research effort between the National Aeronautics and Space Administration and the University of Central Florida (UCF) is exploring how expert systems and imaging technology (laser optical devices) can be integrated into an intelligent, interactive visual data base management system. If expert systems developers think this could be the start of something big, they'd be right: One of the project's goals is to develop a prototype high-definition television expert system.

This article, the first of two, introduces the problem of image management for NASA's space shuttle program and discusses the role expert systems have in the big picture. Part two will appear in a subsequent issue of EXPERT SYSTEMS.

As many as 100,000 color photographs are taken for every space shuttle prelaunch at Florida's Kennedy Space Center. Most of these pictures, called shuttle close-out photographs, are used to establish a baseline from which to evaluate virtually every step of flight preparation for the space shuttle's orbiter, external tank, and solid rocket boosters. Every crucial flight element, subassembly, cable and hardware connection, and layer of insulation is pictorially documented as it is installed, removed, or replaced. These photographic images are then used by engineers from NASA and its contractor companies at the Kennedy Space Center and other locations to verify that essential installation, test, or repair procedures have been completed.

The post-*Challenger* era has made readiness verification and safety for flight a number one priority; in a sense, close-out photographs provide a second and third set of eyes to independently verify that the final preflight configuration is ready for flight. Earlier flight photographs might help to determine whether a new structural fault developed suddenly over a period of time. There are numerous examples of photographs from earlier space shuttle missions providing answers to questions raised during flight readiness preparations.

On other occasions, a sequence of pictures may be needed during real-time space shuttle processing. For example, if an indicator light isn't working properly, a photograph can confirm whether a critical cable connection had been properly made. In many cases, a photograph can eliminate the need to disassemble many layers of insulation and components to physically verify that a cable connection had been completed days or weeks earlier.

The problem of image management

Not surprisingly, 100,000 pictures per launch, multiplied by dozens of launches, leads to the question of how to access and manage an image data base. In their original form, close-out photos exist as 35-mm color negative film slips with 6 to 8 images per slip. Proof pages contain positives of all the images on each roll of film. In addition, multiple 8-by-10-inch

James M. Ragusa is an associate professor of management at the College of Business Administration, University of Central Florida in Orlando. Formerly, he was employed with NASA at the Kennedy Space Center. He can be reached at (407) 275-2915.

Gary W. Orwig is an associate professor at the College of Education, University of Central Florida. He can be reached at (407) 281-5179.

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color enlargements are made of any images that require close inspection.

With the exception of automated film processing, all handling of the images, including the filing system, involves extensive manual labor. Complex problems frequently evolve when engineers attempt to retrieve an individual photo or a group of related pictures because only one true access point is allowed. Without the appropriate accession numbers, pictures cannot be retrieved from the files. Several manual and microcomputer data base management systems assist in the identification of the accession numbers, but even the best of these allow only limited searches based on brief descriptions and key words.

Captions, however, may not fully identify a picture's content and may not reflect evolving terminology used as key words. As a result, the data base does not always provide ready access to needed pictures. In many cases, the success of the retrieval process depends almost entirely on staff members using processing heuristics (i.e., rules of thumb) gained from years of experience. Enter expert systems.

Accessing high-definition images

There is little doubt that expert systems can assist in the collection, classification, storage, and retrieval of high-quality pictorial images that exist in a variety of forms. Images can either be line drawings or photographs. They can be in color or black-and-white, with few or many shades, and may be blurry or sharp. Images may be analog in form, whether they occur as silver and dye on film or as lines of light on a television screen. Of particular interest to the NASA project are digital images, wherein many small picture elements, or pixels, have discrete characteristics that are identified by predefined numeric codes. Computers can process digital images for storage, transmission, and retrieval.

A 35-mm color slide that has been properly exposed and developed is the standard of quality. Although measurements of specific variables such as lines of resolution, color saturation, and maximum light/dark ratio are defined for this medium, for simplicity's sake, any image whose quality is equal to a good slide can be termed a high-definition image.

Text field searches in image data bases

Compared with the advances in alphanumeric expert systems–assisted data base management, remarkably little progress has occurred in the management of high-definition images. Most high-definition image data bases can still be described as manually generated, manually processed, file-cabinet-stored, manually retrieved systems. If alphanumeric information were still treated this way, most modern businesses could not exist. The NASA-sponsored research project is investigating how high-definition images can be processed through a type of expert systems–assisted relational data base management system.

The NASA-sponsored research project is investigating how high-definition images can be processed through an expert systems–assisted relational DBMS.

Elsewhere, too, research is taking place in the design of image and visual data base management systems. K. Meyer-Wegener and others at the Naval Postgraduate School have described a process for image data base management in a multimedia system. These researchers have proposed the use of text description fields in an otherwise traditional alphanumeric DBMS to allow users to indicate the content of images. A structured query language is then implemented to allow users to search the text fields. Software interfaces allow the system to retrieve image files that match queries.

A picture is worth a thousand words

The use of text description fields will be one essential route for classifying and accessing high-definition images. More complicated is the need to access a picture within a picture. For example, an engineer identifies an abrasion problem on a plastic sheathed cable, where it rubs against a metal sheathed cable. Using text searches to locate every occurrence of this situation in an image data base of a machine as complex as the space shuttle would

work only if all appropriate text entries existed. Because any single picture could yield thousands of words of description if this amount of detail were required, the process of describing each picture would be time-consuming, if not impossible, and the resulting text data base would be enormous. A far more logical solution is to locate an example of the problem in an existing image, identify it by drawing a box around it, and then ask the computer to search for any other similar patterns in the entire visual data base.

Image processing and pattern recognition

Although this type of retrieval process is still in development, it does exist. The Query by Pictorial Example (QPE) process allows access to image data bases through image processing and pattern recognition techniques.[1] Using this method, queries can be expressed in terms of pictorial examples.

At present, image processing and pattern recognition of image segments requires advanced computing power. However, even desktop computers can manage less sophisticated image data bases. A prototype image data base system that runs on a standard desktop computer enhanced with image capture boards and write once/read many times (WORM) disk drives is being used to collect information on the next generation of medical information systems. Representatives of the Atlanta Police Department have examined a prototype electronic mug-shot image data base that also uses image capture boards in a standard desktop computer. The Law Enforcement Agency Data System with Pictures is intended to integrate several of the functions associated with collecting, using, and maintaining color mug-shot files.

Intelligent, interactive image management

Advanced image data base management systems might now be practical because the key technologies—standard DBMS systems, expert systems shells, hypermedia software, image digitization, and high-definition video—already exist. In particular, NASA's Intelligent Interactive Visual Data Base Management Systems project that is using space shuttle close-out photography as its case study is targeting an expert systems–driven intelligent management enhancement of image data bases. In addition, the project is identifying the emerging technologies associated with the electronic capture, classification, storage, retrieval, and transmission of high-definition images.

The phase 1 prototype already demonstrates the intelligent retrieval of still images, motion sequences, computer-generated graphics, text, and multiple audio channels.

The project's research objectives can be defined as follows:

- To conduct a systems analysis of a large-scale traditional image processing operation.
- To collect data on critical human and performance factors in the areas of image creation, processing, classification, storage, and retrieval.
- To validate the attributes identified through the creation and testing of prototype models.

Project phases

The project's research areas—systems analysis, image systems, alphanumeric systems, and expert systems—are divided into three phases (see the inset for a complete overview of research objectives). The first phase (year 1), currently under way, is concerned primarily with understanding the dynamics of the existing close-out photography system, developing analog laser disk data bases, and identifying appropriate expert systems technologies. Phase 2 carries over into digital optical systems by evaluating user reactions to prototype analog systems, developing digital expert/laser-optic systems, and linking developed microcomputer systems to a target mainframe. Phase 3 will concentrate on advanced technology associated with data transmission, high-definition television, and related integrating technologies.

Phase 1 began with a collaborative arrangement between UCF faculty and students and

the Lockheed Space Operation Company (LSOC). LSOC, under contract with NASA, has the overall responsibility for all prelaunch and postlanding processing of the space shuttle. Under the agreement, LSOC provides documentation of requirements and procedures of the current photographic close-out system, access to experts who have specific duties associated with space shuttle imagery, and entry into limited-access facilities when required for observation of current processing tasks and methods.

Several methodologies have been and will be used. Case study observations and interviews were used during initial systems analysis activities, followed by individual and group surveys designed to identify critical human and preperformance factors. Both structured interviews and written surveys were used. Similar measures will be used to determine the effectiveness of the prototypes when compared with traditional image processing methods.

Two-stage prototyping is being employed. First, a low-cost prototype will be constructed to collect data not directly related to the quality of the retrieved image. Information from this early prototype will then be used to construct a high-definition prototype that will validate all previous data and collect data specific to the quality of the retrieved image.

Phase 1: An expert photo retrieval system

To date, the research team has scrutinized the close-out process (i.e., authorization, collection, classification, and storage); space shuttle engineers who use the photographs have been interviewed and their comments recorded; and project start-up and purchasing actions have been completed.

On the technical side, a Pioneer Video laser disk player and Texas Instruments expert systems shell have been interfaced through a device-driver software program written in C. The driver controls the activities of the laser device. The working model demonstrates intelligent retrieval of still images and can be used to access motion sequences, computer-generated graphics, text, and multiple audio (i.e., language) channels.

The expert systems shell chosen for this prototype, Texas Instruments's Personal Consultant

Project Research Areas and Phases

Systems analysis

Year 1 Define the current dynamics of the case study system.

Survey existing users of close-out photography.

Year 2 Collect prototype system-improvement information from users.

Year 3 Evaluate a prototype high-definition television (HDTV) expert system.

Image systems (capture, storage, classification, retrieval, transmission)

Year 1 Develop a sample analog video data base of images.

Year 2 Develop sample medium-resolution digital data base of images.

Year 3 Develop picture-within-a-picture capability. Develop a sample high-definition video data base of images.

Alphanumeric systems (traditional data base, text data base)

Year 1 Define current classification and retrieval systems.

Collect existing data keyed to a sample image data base.

Year 2 Link the alphanumeric data base to associated micro and mainframe systems.

Year 3 Develop hypermedia links to the alphanumeric data base.

Expert systems

Year 1 Identify attributes of current expert systems shells.

Develop drivers to link expert systems to the sample image data base.

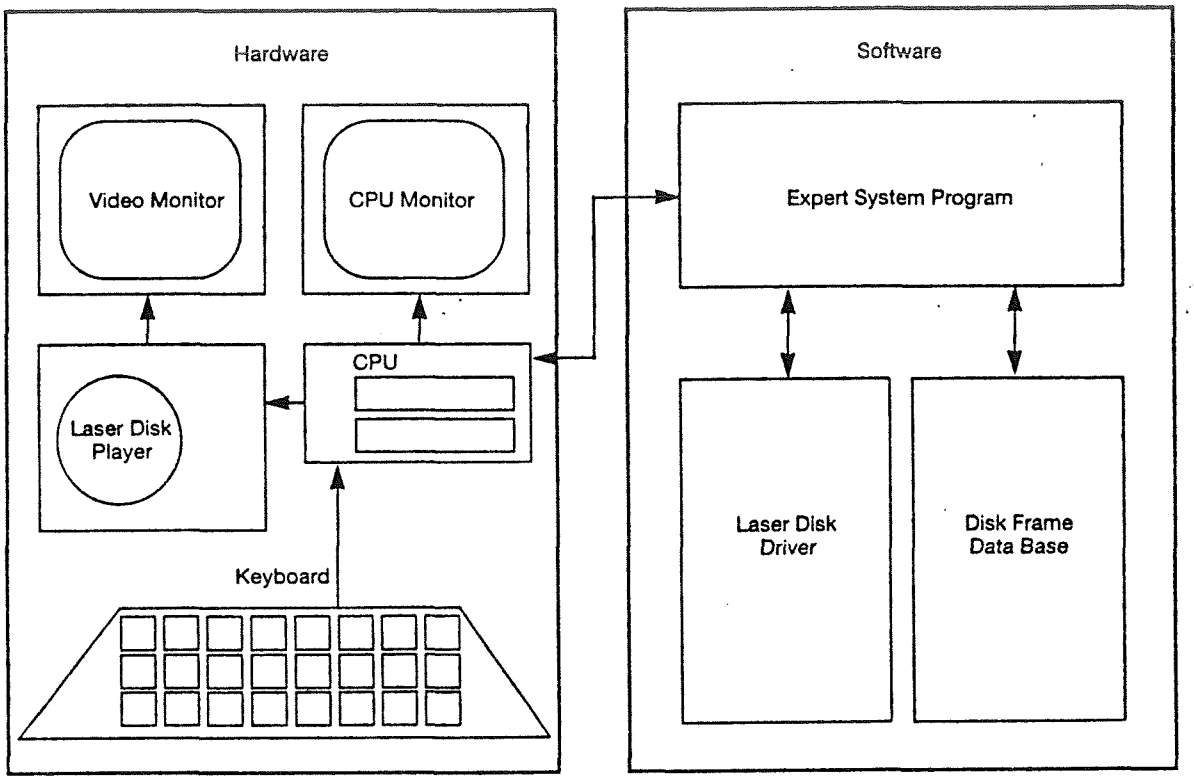
Develop a menu-driven expert system to control image definition data and classification entry.

Develop a menu-driven expert system to assist in retrieval of images.

Year 2 Develop natural language, query-based versions of phase 1 systems.

Year 3 Develop hypermedia links between expert systems and data bases.

Exhibit 1. *Prototype Expert Photograph Retrieval System*



Easy, has the capability to run external programs (.BAT, .COM, .EXE) directly from within the expert systems shell. Exhibit 1 shows the layout of this first analog demonstration system. A dBASE III+ data structure has been constructed that resides between the shell software and the laser disk's internal microcomputer. This data base allows information about the location of laser optical images to be entered directly and maintained through a standard DBMS by modifying expert systems rules.

MBA students from UCF's College of Business Administration have been working with operational personnel from NASA, the Kennedy Space Center, and contractor companies to construct prototype rule-based expert systems photograph classification and retrieval modules. These modules (which share a common dBASE III+ data base) implement an intelligent descriptor-based classification and retrieval system for sample close-out photographs. A full spectrum of commercially available expert systems shells (rule based and object oriented) are being investigated, as well as neural networks, data bases and query languages, and interface devices. Also under study are still video, hypertext, and Intel Corp's Digital Video Interactive (DVI) compact disk technology that can store large amounts of motion video.

Stay tuned

This research is expected to produce a series of standards that define an image DBMS for the collection, classification, storage, and retrieval of digitized color images of a quality users will find to be equal to standard 35-mm color slides. Issues related to analog versus digital collection, storage, and image display are yet to be resolved. Comparisons of expert systems and standard data bases to access images are still being weighed, as is the practicality of locating pictures within pictures

through image-based queries and other techniques. The case study prototypes that evolve from this applications research will, however, ensure that new technology can be integrated within current and planned NASA systems throughout the 1990s. ▲

Acknowledgments

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Appendix F

"Attacking the information access problem with expert systems."

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Attacking the Information Access Problem with Expert Systems

James M. Ragusa and Gary W. Orwig

The growing information needs of many businesses and industries may soon exceed practical paper and magnetic storage capacities. Better storage and retrieval systems are clearly needed. Laser-optical devices (laser disks) under expert systems control can access masses of detailed visual information and standard text quickly, with the added element of interactivity. This article describes the joint applications research being done by the University of Central Florida and the National Aeronautics and Space Administration (NASA) that was introduced in the Fall 1990 issue of EXPERT SYSTEMS ("Expert Systems and Imaging: NASA's Start-Up Work in Intelligent Image Management").

Expert systems and laser-optical devices (laser disks) are being used independently in a wide variety of applications. In fact, each has evolved into a multimillion-dollar industry. When integrated, they can create greatly expanded interactive multimedia applications.

Efforts to interface laser disks and expert systems for intelligent interaction will allow large amounts of information (text and images) to be accessed almost immediately, thus alleviating the information access problem many businesses face. Application potential exists whenever there is a need for the rapid retrieval and low-cost archival storage of multimedia information. Integrated multimedia applications that have been somewhat successful include the commercial kiosk displays frequently seen in shopping malls and hotel lobbies. Kiosks contain the display equipment and the programs that promote interactivity. If designed properly, these public-access displays give users a sense that the system is responding to their needs.

More advanced interactive systems that can attack the information access problem are, however, the focus of both this article and a continuing NASA-sponsored applications research project. Twelve microcomputer-based expert systems shells and five laser-optical formats have been studied, and the general and specific methods of interfacing these technologies are being tested in prototype systems.

Expert systems shells

There are several ways that expert systems can be used within integrated software systems. Some expert systems can provide front-end control. In other cases, the expert system and other program elements share control through their integration. In the design of a prototype integrated system developed by the University of Central Florida and NASA, the expert system is the main controlling program. As such, its function is to call appropriate programs or subroutines that may be written in other languages. This design is possible because most expert systems shells provide facilities for calling other programs and accessing data bases or spreadsheets. For example, access capabilities enable users to extract information from a data base and pass it to the expert system's inference engine, which is a knowledge-

***James M. Ragusa** is an associate professor of management at the College of Business Administration, University of Central Florida, Orlando. Ragusa was formerly employed with NASA at the Kennedy Space Center. He can be reached at (407) 275-2915.*

***Gary W. Orwig** is an associate professor at the College of Education, University of Central Florida. He can be reached at (407) 281-5179.*

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processing software subsystem.

Ten commercially available and relatively small microcomputer-based expert systems shells were selected for in-depth analysis. They are Personal Consultant Easy and Personal Consultant Plus (Texas Instruments Inc), Nexpert Object (Neuron Data), EXSYS (EXSYS Inc), 1st-CLASS (AICorp Inc), Guru (mdbs Inc), VP Expert (Paperback Software International), GoldWorks (Gold Hill Computers Inc), TIMM (General Research Corp), and Level5 (Information Builders Inc). By definition, these shells are expert systems without knowledge bases.

Two large hybrid tools—ART-IM (Inference Corp) and KEE-386 (IntelliCorp)—were later added to this list as microcomputer versions were made available. These popular and robust systems are widely recognized as significant development resources for the workstation environment, and each contains a full range of expert systems development capabilities well beyond those of the smaller shells. The features (retained in the microcomputer versions) include frames, semantic networks, object-oriented programming, blackboard architectures, and dynamic inheritance.

Shell features and interfacing capabilities

The main features of each of the rule-based shells are shown in Exhibit 1. Memory needs range from 256K to 10M bytes. The external interface feature of each shell is a crucial consideration when creating interactive multimedia applications. Although diverse, all the shells provide a mechanism that allows direct technology connection through ASCII codes so that data (e.g., the expert system's conclusions) can be passed to external programs (e.g., the laser disks).

Other parameters less crucial to this research effort are also shown in Exhibit 1, including each product's forward and backward chaining capabilities (i.e., the method of searching rules for drawing or supporting a conclusion), ability to access R:Base (Microrim) and vari-

Exhibit 1. ***Expert Systems Shells and Their Features***

Shell	Minimum Memory (bytes)	External Interface	Forward Chaining	Backward Chaining	Access to R:Base	Access to dBASE	Access to Lotus 1-2-3	Average Retail Price
Personal Consultant Easy	640K	DOS-CALL command	×	×		×	×	$ 495
Personal Consultant Plus	640K	DOS-CALL command	×	×		×	×	2,950
Nexpert Object	640K	Execute command	×	×	×	×	×	5,000
EXSYS	512K	Run ( ) command	×	×	×	×	×	395
1st-CLASS	256K	{ } command	×	×		×		495
Guru	640K	Run ( ) command	×	×	×	×	×	6,000
VP Expert	384K	Call command		×		×	×	245
GoldWorks	6M	SYS:EXE command	×	×		×	×	7,500
TIMM	640K	Linkable objects	×	×				1,900
Level5	512K	Activate command	×	×		×		485
ART-IM	640K	System function	×	×				6,000
KEE-386	10M	LISP function	×	×				9,900

Exhibit 2. *Laser-Optical Systems and Their Characteristics*

Medium	Type	Market	Size	Capacity	Content
Video Laser Disk	Interactive	Training	8 in and 12 in	30 minutes	Analog video and sound
Compact Disk:					
CD-ROM	Interactive	Storage	5 in	650M bytes	Digital data, image, and sound
CDV	Noninteractive	Consumer	5 in	650M bytes	Analog video with 20 minutes of sound
CDI	Interactive	Consumer	5 in	650M bytes	Digital video, text, and sound
DVI	Interactive	Military	5 in	650M bytes	Compressed digital video
WORM Disk	Interactive	Military	12 in	18 minutes	Analog video and sound
Laser Card	Interactive	Business	Credit card	4M bytes	Digital text and graphics
Laser Film	Interactive	Military	12 in	18 minutes	Analog video and sound

ous dBASE versions (Ashton-Tate), and provisions for reading and writing to Lotus 1-2-3 files.

Although prices vary greatly, most expert systems shells have both development and delivery (run-time) versions available. An expert systems application can be created and tested using the development version, then distributed and used in an executable form. With these shells, the delivery version is always much less expensive than the development version.

Laser-optical devices

Five laser-optical formats were studied to determine their compatibility with the expert systems shells. Exhibit 2 summarizes information about these optical media, which are currently available or will soon be introduced on the market.

Current testing and evaluation indicates that there are no significant restrictions to the full integration of these devices with expert systems technology. All of the laser devices described can be linked to expert systems to create integrated applications.

Video laser disks. Video laser disks are produced in several forms; the most accepted is LaserVision, which reflects a set of specifications that laser disk manufacturers have established. An array of programs and players are commercially available in this format. The main drawback is that programs must first be produced on a master tape, which must then be sent to a special facility for conversion to disk. As a result, several noncompatible formats have been developed that allow direct recording from desktop recorders/players and are priced from $10,000 to $20,000.

Compact disks. Compact disks, the same format used for musical recordings, are used primarily as the storage medium for a variety of alphanumeric and image presentation systems. CD-ROM (compact disk–read only memory) is used for read-only storage of massive amounts of digital data. Information can be stored as images (up to 15,000), text (10,000 pages), or sound (30 minutes). CDV (compact disk video) is an evolving medium designed to present segments of motion video with high-quality sound.

Two new compact disk technologies are emerging. CDI (compact disk interactive) can present sound, data, still images, and motion. It uses a dedicated player that appears to be directed mainly at the consumer market. DVI (digital video interactive) is similar to CDI but is designed to work with advanced personal computers. It also appears to offer superior motion video at this stage of development. Currently, to produce any form of compact disk, finalized data tapes and videotapes must be sent to a specialized facility for conversion.

WORM disks. Write-once/read-many (WORM) disks, now available from several manufacturers, function as if they were very large capacity hard disk drives that can be written to and read from but not erased. Because of these characteristics, they are useful for storing archival data (e.g., business records) that need updating.

Laser cards. Laser cards are credit card–sized devices containing an optical stripe that stores digital information. A special reader connected to a monitor is used to access data.

Laser film. The primary advantage of laser film is that the disk, which is made of photographic film, can be recorded in real time and duplicated rapidly. The need for special equipment, however, has limited the medium's success.

Interfacing

Interfacing laser-optical devices and expert systems shells is accomplished with a device driver software written to control and query the functions of the laser device. The device driver program may be written in any language supported within the personal computer environment, including C, Pascal, Ada, FORTRAN, and LISP. To control the laser device from within the expert systems application, the expert systems shell must be able to access the laser device driver program. Typically, expert systems shells can call an external program that will perform an activity not supported by the shell. Each of the 12 expert systems tools listed in Exhibit 1 can run any other external programs (e.g., .BAT, .COM, or .EXE) directly from within the shell.

To control the laser device from within the expert systems application, the expert systems shell must be able to access the device driver software.

To provide full functional access to the laser device, the expert systems shell must be able to send standard commands as well as data through the laser driver. The commands tell the driver what action to request—for example, seek a still-frame display from a laser disk. To reduce delay times, the expert systems shell should allow data to be stacked in memory. If, instead, each command requires access to a hard disk or diskette drive, performance will suffer. With the exception of EXSYS, all of the expert systems shells studied can pass data to an external driver program through memory. EXSYS passes data to an external program by writing to a text file called "PASS.DAT". The called program—in this case, the laser driver—must read the "PASS.DAT" file to determine the requested action to perform.

Each expert systems shell formats data differently. Therefore, for device driver software to be shared by multiple expert systems shells, it must allow configuration selection for the shell used. Because most of the expert systems shells pass data in an ASCII format, the device driver should accept ASCII commands. In addition, it must convert the data to a correct form (configured for the shell selected) to process the commands. For example, to play a segment of a laser disk, the expert systems shell fires a rule that invokes an external program by passing the command syntax to play the disk. To perform this using Texas Instruments' Personal Consultant Plus shell, the following syntax is used: DOS-CALL "LASER" "PLAY FROM 1200 TO 1300". The external program "LASER" receives a request to play a segment of the laser disk from frames 1,200 to 1,300. To function properly, the laser disk–expert systems shell configuration must be selected as Personal Consultant Plus.

With expert systems shells that can access external data bases, such specification data as frame numbers can be stored in an external data base rather than in rules. This method is used in the latest version of the prototype integrated system.

The laser disk device driver interface

The laser-optical device selected for this research effort, an industrial-grade Pioneer LD-V8000 player, is controlled through a standard RS-232 data interface. Personal Consultant Plus is the expert systems shell in the current prototype. Laser disk operation is maintained by sending the laser disk player the proper ASCII character sequences. Exhibit 3 lists the control functions and their commands.

The laser disk control program is written in the C programming language for portability. The device driver accepts the commands that allow the expert systems shell to access and play still frames as well as specific segments of the laser disk. For this application, a commercially available laser disk was selected.

Exhibit 3. ***Laser Disk Functions and Commands***

Function Performed	Commands
Pause play action (picture ceases)	"PAUSE"
Start play action (audio and video signals played)	"PLAY FROM *** TO ****"
Step forward or backward a frame at a time	"STEP FORWARD" "STEP BACK"
Scan forward or backward	"SCAN FORWARD" "SCAN BACK"
Play at a specified speed	"SPEED ***"
Seek a particular frame address	"SEEK ***"
Display a still frame	"PLAY ***"
Control the audio and video signals	"AUDIO STEREO" "AUDIO CH1" "AUDIO CH2" "VIDEO ON" "VIDEO OFF"

Applications potential

Proven applications of expert systems technology can be found in business (including a large base of financial services), the aerospace and defense industries, education, the arts and sciences, and production and operations management. Several significant production-related expert systems have been put into operation in the US. These systems have one feature in common: they resulted in improvement of at least one order of magnitude over the original production method. Du Pont has an expert system for purging a distillation column of chemical impurities, and Westinghouse Electric has a system for diagnosing steam turbine generator problems. FMC Corp has introduced an expert system that helps prevent equipment failures and reduce waste production in the manufacturing of phosphorus. FMC's system also helps control costs. Digital Equipment Corp's VAX expert configurator, XCON, has spawned similar systems, including the truck configuration system used by Navistar International. Northrop Corp has a knowledge-based system for translating engineering drawings into a detailed plan for manufacturing complex aircraft parts.

Contemporary pressures and the need for expert systems applications are being addressed elsewhere in the world as well. In 1987, *Japan Computer Quarterly*, a publication of the government-sponsored Japan Information Processing Development Center, reported:

> **"In Japan we have developed what might be called 'expert systems fever.' In the world of Japanese industry, there are well over a hundred expert systems that are either already being put to practical use or soon . . . [will] be. Industries engaged most actively in the research and development of expert systems are steel, electric power, manufacturing (particularly the automobile industry), and construction. These are also the industries with the most expert systems in operation. Expert systems now under development are advanced enough for use in strategically important applications like design and planning."**

Within the Japanese market, steelmaker Nippon-Kokan has an expert system that interprets data from thousands of blast-furnace sensors. Toyota has developed a system to advise high-level technicians on automobile diagnosis and repair. Canon uses an expert system to design zoom lenses, and Kajima has developed an expert method for selecting piling material for building foundation construction.

Interest in integrated applications

In many respects, the applications research described in this article is an extension of a theme introduced in 1988 at the American Production and Inventory Control Society's international conference. Focusing resources for competitive advantage was the basic theme chosen by the conference committee. Today, interest is being shown in integrated knowledge-based, laser-optical systems that can help

Exhibit 4. ***Potential Integrated Applications***

Consumer Services

Service center advice
Car buying advice
Do-it-yourself home and car repair
banking service advice
Real estate selection
Plant care advice
Interior design advice

Travel, Tourism, and Recreation

Vacation selection
Outdoor recreation and camping site selection
Entertainment options
Hotel and restaurant selection
Map and route guidance
Golf course selection

Law Enforcement

Mug shot identification
Evidence inventory
Prison inmate education
Accident reconstruction
Vehicle identification
Crime scene records
Evidence presentation

Human Resources

Employee orientation
Loss prevention training
Company orientation
Skills training
Management development
Customer orientation

Marketing

Product identification and display
Customer and dealer information
Convention center selection
Electronic catalogs
Sales presentations
Distribution advice

Education and Training

Intelligent computer-aided instruction
Medical and paramedical training
Military simulation training
Customer service training
Teacher preparation
Adult literacy education
Language training
Library training
Sex education

Other

Architectural design assistance
Accounting audit reference storage and retrieval
Public works design
Urban planning
Landscaping

companies achieve a competitive advantage (see Exhibit 4 for potential integrated applications.

NASA and its contractors recognize the promise and advantages of linking these technologies as they develop applications for current and future space shuttle programs. NASA and the Kennedy Space Center have provided research applications funding to the University of Central Florida to explore the potential for the intelligent classification, storage, and retrieval of shuttle ground-processing close-out photography. NASA's need is significant because approximately 100,000 photographs have been obtained for each of the 35 shuttles processed at the Kennedy Space Center to date. Other NASA applications yet to be explored include intelligent computer-aided instruction, simulation and training, human resources development, and performance measurement. Additional processing-related opportunities include inventory management, planning and control, operations management, purchasing, quality control, distribution, and logistics.

A visual industrial data base

Video laser disks have been synonymous with interactive applications for many years now. Several years ago, Digital Video Corp worked with Westinghouse's transportation division on a prototype interactive parts maintenance system. This hardware and software system used standard alphanumeric data bases and a visual data base on video laser disk to allow engineers to quickly identify and order replacement parts for light-rail transit systems. The visual data base consisted of a pyramid structure of enhanced technical drawings. AT the top of the pyramid was a top-level or overall drawing of a transit car. Successive layers of the pyramid structure provided additional levels of detail for the functional units of the cars, with the final or bottom layer consisting of images of individual nuts, bolts, and indicator lamps. Using a light pen, an engineer could point to areas of the screen drawing where detail was needed, and a lower-level image would appear for that part of the transit car. After a few selections, the engineer could have a picture of the needed module or device; an adjacent monitor provides all the necessary ordering information from the standard alphanumeric data base.

Although field testing of this experimental system had highly positive results, the system had its limitations. Engineers often wanted to

take alternate paths through the images, or they wanted to view collections of images that contained similar components but in different areas of the transit car. When this system was developed, microcomputer-based expert systems shells were not readily available. If the system were developed today, alternate search strategies would be much easier to prototype and implement.

Production and operations

In production and operations, the applications potential is broad. A partial list of applications includes product planning, manufacturing resource management, and process design (e.g., computer-integrated manufacturing, location and layout selection, and materials and inventory management). Master production scheduling (MPS), material requirements planning (MRP), just-in-time (JIT) inventory, project scheduling and control, shop floor control, quality management and control, and distribution and logistics applications are also possible.

The area of process design, for example, includes the selection of input, operations, work flows, and methods. Assuming an expert system based on the knowledge of the organization's expert process designer were available, another designer (not necessarily the best design expert) could begin the design process. Connected to a laser-optical device, complete access to motion and still sequences, text and graphics, and sound would be possible. The current process, potential problem areas, available resources, vendors, work flows, and existing methods could be reviewed. What-if interaction with the resource base of knowledge and information would be a significant asset for this process. The results of an analysis could be recorded for future use to a WORM disk or laser-card device.

In another situation, integrated technology could be developed for the high-level training of new personnel or the upgrading, recertification, and cross-training of existing personnel. If the training applications were equipment setup or changeover problem solving, motion and still sequences, text and graphics, or sound could be employed in the program. Interactive computer-based training would allow standardized instruction, correction, testing, and remediation. If equipment setup is the target, previous methods and techniques could be displayed and described by the system. After testing and evaluation, the trainee's performance could be determined by the expert system's evaluation algorithm with scores recorded on the laser data base. The end result would be standardized training, flexibility, and improved performance with reduced participation by human instructors.

Conclusion

This article presents results of applications research directed at finding an improved method of storing and accessing information. One solution involves the synergistic interfacing of expert systems shells and laser-optical devices. A prototype system has been developed to prove the feasibility of integrated systems. They are not only possible but desirable if a competitive advantage is to be achieved. ▲

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Appendix G

"Object oriented databases"

OBJECT-ORIENTED DATABASES

by

Russell A. Wielgos

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INTRODUCTION

Traditional database systems were developed in the mainframe environments of the early 1960s. They were usually applied to numeric and record-based data, such as employee records and parts inventory. During the 1970s, on-line information systems became popular and were used for full-text searching of textual databases. Expert systems technology was developed in the mid-1970s and then, in the late 1970s and early 1980s, techniques related to object-oriented programming grew out of advances in software engineering, user interfaces and high-level languages.[1]

These object-oriented concepts offer significant advantages to the programming and data modeling business. Some of these advantages include the ability for user programming, easier maintenance and updating of software, and the ability to share data and procedures among applications and networks in a modular, reusable fashion.[13]

The basic idea behind the object-oriented approach is that objects are seen as self-defining components that incorporate not only data, but also, descriptions of their behavior and of their relations with other objects. Object classes can be divided into subclasses via inheritance. The concept of inheritance, which will be described more fully later on, allows similar procedures to be invoked without all new code needing to be written for each.

Also, because objects can be manipulated and altered without having to rewrite any code, the benefit of true end-user programming is built into object-orientation.[13]

Another unique characteristic of the object approach is that it more closely simulates the way people think and function than do procedural systems. It is a method of telling the computer how to conceptually represent and manage information about the real world.[3] This helps to free individuals from the need to think like a computer, instead, encouraging groupings according to common-sense categories and procedures.[13]

Foundational object-oriented concepts have evolved in three different disciplines: first in programming languages, then in artificial intelligence, and then in databases.[8] This paper will focus on the database concepts of object-orientation, while also, briefly touching on the artificial intelligence concepts.

OBJECT-ORIENTED DATABASE CONCEPTS - NATURE OF THE TECHNOLOGY

In object-oriented databases, an object is a thing which exists and has identity, such as a microwave located in the kitchen or Richard Nixon. These objects, unlike an item in a relational database, are persistent, i.e., they can survive multiple sessions or transactions.[12] Every object has a specific state and behavior. The state of the object is defined as the set of values for the attributes (i.e. ON/OFF, etc.) and the behavior of an

object is the set of methods, or programming code, which operates on the state of the object.[8]

A group of related objects make up an object class.[14] A microwave oven, a group of rooms, or a set of people, are all examples of object classes. Objects belonging to the same class are called instances of that class. A class describes the form (attributes) of the instances, and the operations (methods) applicable to each instance.

Some of the other fundamentally important aspects of object-oriented databases are the concepts of inheritance, object identifiers, messages, encapsulation and version management. These concepts will be discussed next.

All subclasses of a class inherit all of the properties defined by that class, and can also have additional properties local to them.[17] This powerful concept, called inheritance, is a technique for obtaining information from an object's parent class. It is helpful in that it reduces the need to specify redundant information, while also, simplifying the updating process, as information about many object instances can be changed and entered on a single update action.[5]

In the concept of object identifiers, object-oriented databases are very much similar to network or hierarchical databases. They each use the notion of pointers.[12] The object identifier is a logical pointer which is used to pinpoint an

object to retrieve.[8] It is the property of an object that distinguishes it from all other objects and is independent of content, type and addressability.[9]

A message represents the interaction between objects.[5] Instead of naming a procedure to perform an operation on an object, the object is identified and a message is sent to it. A selector in the message specifies the operation to be performed and the object that receives the message is then responsible for deciding how to respond using its own methods for performing the requested operation.[10]

Encapsulation is an abstraction mechanism which accesses the object and modifies it only through external interface routines and operations. The internal implementation details, data structures, and storage elements used to process the object and its operations are invisible to the user, thus helping the object-orientation to reflect reality more closely.[9]

Another important concept of object-oriented databases is the concept of version management. In some applications, the same object undergoes multiple changes or state transitions, and it is often desirable to access or investigate previous states of the object.[7] This version management is handled by archiving old versions of the objects and later returning them, using their unique identifier and time-stamp or version number.[5]

OBJECT-ORIENTED VS. RELATIONAL DATABASES

Currently, less than 10 percent of the World's computerized data is stored in a data base.[5] This fact, most likely, is due to the inability of currently available database management systems (DBMS) to provide the data modeling and retrieval facilities required by most computer users.

The "Third Generation Database System Manifesto", authored by several relational database experts, decrees that the 1970s was the era of the first generation - the hierarchical database; the 1980s was the era of the second generation - the relational database; and that the 1990s will be the era of the third generation - an extension of the relational database.[12]

According to the Manifesto, the third generation database will have 3 basic requirements:

1.) It must accommodate a broader range of data types, such as images, multimedia documents, video and other "objects".
2.) It must support the positive features found in the second generation relational databases, such as non-procedural access and data independence.
3.) It must communicate and be interoperable with distributed DBMSs, C programs, business applications, UNIX commands, software engineering tools, etc.[12]

These relational database experts never even mentioned the words "object-oriented", thus the battle has begun. On one side the evolution seekers, i.e. the relational database guys vs. the revolution seekers, i.e. the object-oriented guys.

Vendors of object-oriented database systems such as Object Design Inc., Ontologic Corp. and Servio Corp. claim that their products perform more than twenty times better than relational databases for such applications as CAD and CASE.[20] They would like to see their technology replace all the less effective relational databases.

The relational database supporters feel, that if a change is necessary, that the object-oriented technology should be added on to their time-tested relational systems, not replace them. According to David Beech, senior architect at Oracle Corp, one of the first relational database suppliers, "The object model is just an extension of the relational model, and having yet another type of database system in shops raises a lot of problems."[20]

Object-oriented vendors refute this by replying, "We've built a Porsche from the ground up, while they're still strapping boosters on a Ford Fairlane and saying it will go just as fast."[20]

Perhaps the best way to solve this type of confusion is to look at the various differences in the two database models. Lets give it a try.

Besides the fact that object-oriented databases introduce a whole new set of concepts, such as the aforementioned inheritance, class, method and message, there are some other very real and clear distinctions between the two databases.

For example, relational databases are based on a mathematical

theory, while object-oriented databases use a navigational model of computation. The relational crowd criticizes this navigational model by asking, "How do they traverse complex structures (objects)?" They claim that it is a "back-to-the-future" technique from the world of hierarchical databases. Object-orienters argue that the advantage of navigation is that it is easier to weave your way through objects that model the real world rather than tables, tuples and records, which do not allow for a nested structure and view of a design.[12] Furthermore, there are important applications from computer-aided design and artificial intelligence which absolutely MUST navigate through large databases.[8]

Another difference between the two is that relational databases are too limited for a large class of applications. These applications, characterized as complex, large scale, and data intensive, need a database model that is more expressive and flexible than a relational model. Object-oriented databases are being developed to meet the data handling needs of such applications. This is helped by the way object-oriented databases can store class definitions and instantiations of these classes.[6]

The way applications must query information in a database is also handled quite differently between the two models. In the relational model, an application sends a query to a database which then returns a number of values. These values are typically stored in the application's data structures, manipulated in these structures, and then shipped back to the database to be stored.

This flat nature of relations makes it difficult to model complex object networks. Instead, the mimicking of hierarchies with identification keys instead of pointers or direct references are necessary.[6]

In the object-oriented world, however, a program sends a message to an object in the database to manipulate its data, compute some value, and/or to return something, such as a reference to another object in the database.[6]

In a related issue, because complex objects are stored in a series of relations, a number of queries need to be applied to retrieve a single object from a relational database. These queries are applied sequentially, with one query depending on the result of the previous query. On the other hand, with an object-oriented database, sending one message can take the place of performing many relational database queries. In other words, messages can invoke other messages, thereby alleviating the problem of sequential queries in relational databases.[6]

In terms of relational schema, relational database systems represent the database schema in the form of a set of relations, including a relation for all other relations in the database. This schema is much more difficult to represent and maintain in an object-oriented database, since the schema is no longer a simple collection of largely independent relations, but a collection of classes which are interrelated to one another through generalization and aggregation relationships.[8]

Hypermedia, being a hot topic of the day, is also being brought up as a definite fault of relational databases. Unlike object-oriented databases, relational databases cannot provide direct, natural representations of graph-structured object spaces. Because object spaces are flat tables, complex relationships between multimedia products and objects cannot be expressed directly.[9] This may serve to be a major flaw of relational databases in the near future.

A number of other differences between the two databases models exist, surely enough to concentrate an entire paper on, but here only some of the more obvious ones were brought out. From this discussion, the reader can see that each model has its own set of strengths and weaknesses, and each model should only be evaluated based on the application to serve.

USERS OF OBJECT-ORIENTED DATABASE TECHNOLOGY

People who are developing object-oriented applications will increasingly want to store and retrieve instances in databases.[4] The main target, thus far, of object-oriented databases has been the engineering, computer-aided design (CAD), computer-aided manufacturing (CAM), computer-aided software engineering (CASE), and office automation markets. These applications all have characteristics different from traditional business or accounting applications. CAD, CAM, CASE and office

automation applications use such large amounts of data that it is nearly impossible to cluster the application's related data.[7] A number of these object-oriented database applications and prototypes will now be described in more detail.

One of the earliest object-oriented database products was G-BASE which was introduced by Graphael in 1987. It is a Lisp-based system with entities and methods defined using Lisp syntax. G-Base supports abstract data typing and multiple inheritance of classes. The G-Base environment also includes an interactive graphical object browser, interactive report generator and declarative query language. G-Base, also, provides elegant modeling, browsing, and querying capabilities for bulk data, but the early versions did not support multi-user transactions or versioning.

The Gemstone object-oriented database, from Serviologic, was one of the earliest to provide strong support of object identity, inheritance, and encapsulation, coupled with many database capabilities such as persistence, transactions and ad hoc querying.[7] Gemstone was created with components of C and Smalltalk.[3]

Iris, developed at Hewlett-Packard, is a next generation DBMS research prototype which supports inheritance, abstract data and referential sharing of objects.[19] It is based on functional data models and includes an object-oriented extension

of SQL, called Object SQL.[7] Iris, designed to meet the needs of rich modeling constructs, also supports direct data support for inference, novel data types, lengthy dynamic data base interactions spanning over days and many versions, and interfaces with many object-oriented programming languages.[2] It was built with the intent to meet the needs of new and emerging database applications such as office automation and knowledge engineering, engineering test and measurement, and hardware and software design.[22] Each of these applications require a number of capabilities which are not supported by the current generation relational databases.[19]

OZ+, developed at the University of Toronto, merges object-oriented programming concepts derived from Smalltalk and is intended for use in modeling office activities which will provide efficient methods for storage and retrieval of persistent data in a multi-user office. OZ+ employs object-oriented programming concepts with a slight variation, such as objects, contents (the object's data), and rules (the object's operations), events and messages. The OZ+ system prototype was implemented on a SUN 3/50.[2]

And finally, the ORION prototype object-oriented database system, developed at Microelectronics and Computer Technology Corporation, is a single-user, multitask database system intended for applications in artificial intelligence, multimedia documents for office automation, and computer-aided design. It is filled

with advanced features, such as version and change notifications, transactions management, and multimedia management. Orion was implemented in Common Lisp on a Symbolics 3600 machine and on a SUN UNIX workstation.

As expected, with object-oriented databases being relatively new to the business world, there is not yet a large following or a great number of users for the object-oriented database. The prototypes, discussed above, have served as great research in the area and will eventually prove to be quite helpful in publicizing this new technology.

MIS OPPORTUNITIES FOR OBJECT-ORIENTED DATABASES

As previously stated, object-oriented databases are currently being used for such applications such as computer-aided design (CAD), computer-aided software engineering (CASE) and office automation. These types of applications may also, occasionally, fall under the category of MIS applications.

Object-oriented databases attempt to satisfy the needs of users whose applications need the following features:[5]

- a variety of data types and type constructors
- modelling accuracy
- derived data
- set value attributes
- the ability to model actions

Object-oriented databases do not attempt to solve acknowledged data-modeling problems such as:[5]

- temporal and spatial logic
- incomplete information
- conflicting information
- system self-knowledge
- common-sense knowledge

Much of the research and use of object-oriented databases, done until now, has been related to more technical areas than MIS and business. Due to the complexity of the technology, I do not see this changing very much, in the near future, except in cases of applications needing the above features. I believe that relational databases or their third generation "big brother" will fulfill most of the World's MIS needs for years to come.

ECONOMIC IMPACT OF OBJECT-ORIENTED DATABASES

The one big economic impact, which I view object-oriented databases to have on the computing industry, is the decreasing reliance on the computer programmer. This trend, helped along by the arrival of the fourth-generation languages, will continue with object-oriented databases, due to the technology's ability to put the application programming in the hands of the user. This will leave the programmer more expendable, at the application level.

Object-oriented databases will also be able to save corporations money, due to its improvements over the current relational database technology. Any technology which is more

efficient and serves the company's purpose better than before, will end up saving the company money, in the long run.

FUTURE OF OBJECT-ORIENTED DATABASES

Object-oriented databases are still an excellent area for further research and standardization. First of all, there is a clear need to formalize and/or at least standardize the object-oriented concepts, if a true foundation is to be laid.[8] There also exists no formal model for queries made to object-oriented databases.[17] In order for this technology to be widely accepted, these fuzzy areas must be rectified and according to researchers, various standardization attempts are currently underway.

Object-oriented databases are also moving into the area of hypermedia. In the proposed Object Composition Petri Net (OCPN) model, researchers are attempting to approach the area of object storage and retrieval for multimedia synchronization. This model is expected to reveal an elegant approach to interfacing general multimedia services to databases.[18]

Another exciting area which object-oriented databases may move into, in the near future, is the area of intelligent databases. An intelligent database is one that "manages information in a natural way, making that information easy to store, access and use".[9] The emphasis is on information rather than data because these databases incorporate not only traditional applications, such

as inventory management, but also automatic discovery systems, imaging applications and knowledge bases.[9]

According to Khoshafian, "In the evolution of databases and data models, object-oriented databases form an important and necessary phase. The future of databases, however, is in intelligent databases."[7] Intelligent databases represent a new technology for information management that has evolved as a result of the integration of such diverse fields as: object-oriented concepts, expert systems, hypermedia and information retrieval.[7] (See figure 1). Khoshafian predicts them to be the single most important component in the integrated environment of the 1990s.[9]

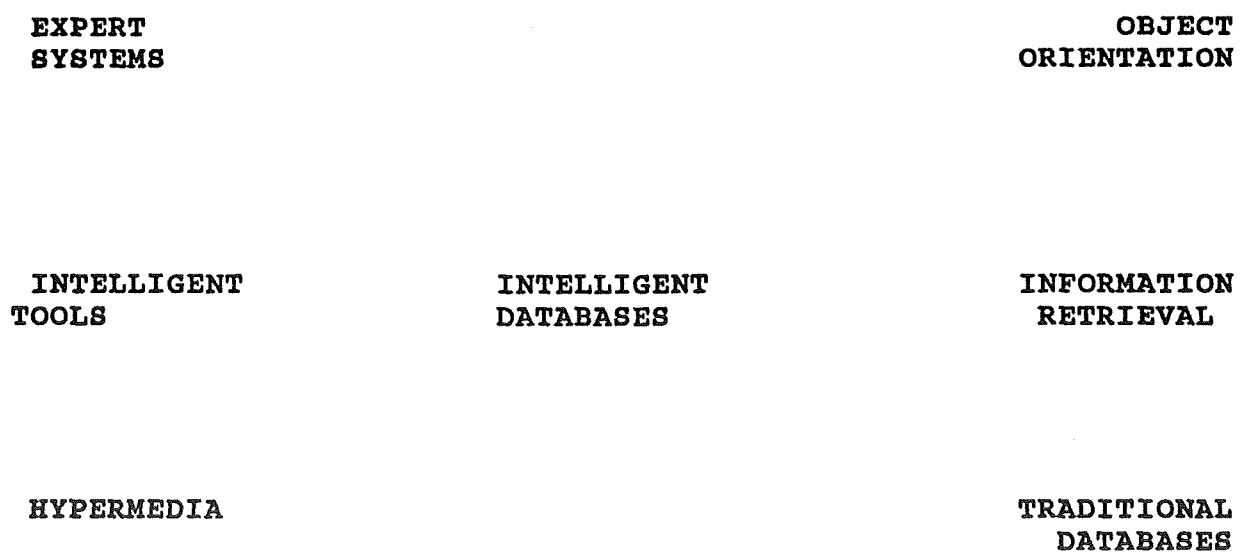

FIGURE 1

CONCLUSIONS

As this paper shows there are still many hours of research to be spent before object-oriented databases will be the savior that some may see it to be. There is a strong need for object-oriented database standards to be drawn up so that all research can end up serving the same coordinated purpose. Perhaps this would help speed up the research process.

Having served as a computer professional myself, brought up in the era of structured programming and assembler, I find object-oriented concepts to be a whole new and sometimes confusing technology, but it certainly may have some advantages over relational types. This will be left for the researchers to decide, but PC Week did have this prediction:

> "Few observers expect object-oriented database management systems to replace relational databases. ODBMS outperforms relational systems for handling complex data such as engineering diagrams and bitmapped graphics, but relational databases are better for transaction-oriented applications such as account updates," said Rick Cattell, a distinguished engineer and ODBMS expert, at Sun Microsystems Inc. "I think the technology is going to take off in a limited domain. The market that these folks are initially addressing is maybe ten percent the size of the business data-processing market."[20]

As with many other recent technologies, such as artificial intelligence or neural networks, it again looks as though only time will tell, if and when, this object-oriented technology will end up turning into the helpful technology we hope it will, or end up being lost in the shuffle, as was the case for many of the early robotics efforts. Hopefully, unlike robotics, object-oriented databases will live up to its potential.

ANNOTATED BIBLIOGRAPHY

[1] **J. Shandle, "Will Vendors Line Up Behind Objectivity?", Electronics, April 1990, pp. 66-67**

This article explains the vendors' point of view on the object-oriented data base technology. Basically, it says that the technology is still two years from being widely incorporated in the product sectors and it will definitely be helpful in the CAD and CASE applications.

[2] **David Hu, "Object-Oriented Environment in C++", Management Information Source, Inc., 1990, pp. 456-466**

This book discusses the object-oriented environment in the C++ programming language. The pages referenced spoke of object-oriented DBMSs and intelligent databases. Several object-oriented database prototypes are discussed.

[3] **J. McCaskey, "Object-oriented database keeps the house in order", Electronic Design, March 19, 1987, pp. 129-134**

This article discusses the strengths of object-oriented databases and programming and explains their use in the simulation world.

[4] **P. Harmon, "Object-Oriented Systems", Intelligent Software Strategies, Volume VI, No.9, pp. 1-20**

This monthly newsletter on expert systems, OOP, CASE, Neural Networks and Natural language, put out by the Cutter Information Corp., covers such topics as object-oriented: systems, programming, products, CASE tools, interface tools, CAD/CAM development tools and product vendors.

[5] **M.A. Garvey and M.S. Jackson, "Introduction to object-oriented databases", Information & Software Technology, December 1989, pp. 521-527**

This paper is a tutorial introduction to object-oriented databases. It describes the background of object-oriented databases and outlines the rationale for this approach. Applications are also discussed.

[6] **K. Smith, and S. Zdonik, "Intermedia: A Case Study of the Differences Between Relational and Object-Oriented Database Systems", OOPSLA '87 Proceedings, Oct. 4-8, 1987, pp. 452-465**

This paper compares two approaches to meeting the data handling requirements of Intermedia, a hypermedia system. Intermedia, written using an object-oriented programming

ANNOTATED BIBLIOGRAPHY, CONTINUED

[6] cont language, relies on a traditional relational DBMS for data storage and retrieval. The ramifications of replacing the relational database with an object-oriented database are also discussed.

[7] **S. Khoshafian, "Insight into Object-Oriented Databases", Information & Software Technology, May 1990, pp. 274-289**

This article explains that object-orientation provides a more direct and natural representation of real-world problems. It explains the basic concepts of the technology and also discusses intelligent databases, in depth.

[8] **W. Kim, "Object-Oriented Databases: Definition and Research Directions", IEEE Transactions On Knowledge Engineering, Sept. 1990, pp. 327-341**

This article gives a basic foundation of the object-oriented database using results obtained from the ORION series of object-oriented database systems. Future research direction is also discussed.

[9] **S. Khoshafian, K. Parsaye and H. Wong, "Intelligent Database Engines", Database Programming and Design, July 1990, pp.56-65**

This article explains how DBMS technology will evolve in order to handle such new technologies as hypermedia, object orientation and other new business needs. Relational, object-oriented and intelligent databases are discussed. The factors associated with object-oriented databases are also explained.

[10] **F. Manola, "Object-Oriented Knowledge Bases, Part I", AI Expert, March 1990, pp. 26-36**

This article explains the history of DBMS concepts and explains how object-oriented concepts can be used to address the requirements of KBIIS systems and information processing resources.

[11] **F. Manola, "Object-Oriented Knowledge Bases, Part II", AI Expert, April 1990, pp. 46-57**

This continuation article explains the DOM (distributed object manager) technology and its tools and applications. Knowledge-based processing and HDDBMS intergration are also discussed. Object-oriented database technology's application in integrating KBIIS, is also on the agenda.

ANNOTATED BIBLIOGRAPHY, CONTINUED

[12] **C. Stone and D. Hentchel, "Database Wars Revisited", Byte, October 1990, pp.233-242**
The article explains the differences between relational and object-oriented databases and describes how experts feel about the eventual third generation databases.

[13] **J. Blackford, "The Story Of 'O'", Personal Computing, June 29, 1990, pp. 83-85**
This article gives a brief overview of the object-oriented concepts, including databases, programming languages, operating systems and environments.

[14] **E. Sibley, "Relational Database Design Using An Object-Oriented Methodology". Communications of the ACM, April 1988, pp. 414-424**
This article explains the object modeling technique approach to relational database design. A comprehensive explanation and two applications show the semantic improvements of OMT over other approaches. Basic object-oriented approaches are also discussed.

[15] **K. Lindsay, "Expert Systems in the CIM Environment", Sterling Publications, 1987, pp. 6-7**
This Intellicorp Technical Article provides a comprehensive view of Computer Aided Manufacturing (CIM) and discusses some of the techniques, developed within the field of AI, which can be applied to accomplish the computer integration of a manufacturing enterprise. AI, object-oriented data management and CAM Net are also discussed.

[16] **F. Staes and D. Vermeir, "Browsing a la carte in Object-Oriented Databases", The Computer Journal, Vol.32, No.4, 1989, pp. 333-340**
This paper presents a user interface to the KIWI object-oriented database system. OOPS+, browsing and querying are also discussed.

[17] **J. Banerjee, W. Kim and K. Kim, "Queries In Object-Oriented Databases", IEEE, 1988, pp. 31-37**
This article develops a model of a query under an object oriented data model and analyzes the fundamental differences between queries in relational and object-oriented databases.

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[18] **T. Little and A. Ghafoor, "Multimedia Object Models for Synchronization and Databases", IEEE, 1990, pp. 20-27**
This article proposes a technique for formally specifying and modeling the temporal composition of multimedia data. The proposed model is based on the Timed Petri Nets and the logic of temporal intervals.

[19] **W. Kim and F. Lochovsky, "Object-Oriented Concepts, Databases and Applications", ACM Press, 1989, pp. 219-340**
This book discusses all aspects of the object-oriented technology, including databases, programming, modeling and applications.

[20] **P. Sherer, "ODBMS Upstarts Challenge Relational Database Ground", PC Week, Oct. 15, 1990, pp. 61,65**
This article discusses the differences between the relational database followers and the object-oriented followers. The article gives both sides of the quarrel of which type of database will end up being the next third generation database.

[21] **H. Afsarmanesh and D. Mcleod, "The 3DIS: An Extensible Object-Oriented Information Management Environment", ACM Transactions On Information Systems, Oct. 1989, pp. 339-377**
This article explains the 3-Dimensional Information Space (3DIS) object-oriented framework for information management and how it is specifically oriented toward supporting the database requirements for data intensive information system applications. The article describes the related research and object specifications, as well.

[22] **D. Fishman, D. Beech and H. Cate, "IRIS: An Object-Oriented Database Management System", ACM Transactions On Information Systems, Jan. 1987, pp. 48-69**
The IRIS DBMS is a research prototype of a next generation DBMS intended to meet the needs of new and emerging database applications, including office automation and software design. This article discusses IRIS in detail, including its content, needs and capabilities.

[23] **M. Hernick and S. Zdonik, "A Shared, Segmented Memory System for an Object-Oriented Database", ACM Transactions On Information Systems, Oct. 1989, pp. 70-95**

This article describes the basis of a object-oriented database and the basic architecture of the system implementing it. Segmented and transaction schema of architecture are present, as well as, object access, replication and clustering.

Appendix H

Potential applications: Interfaced expert systems/laser optics technology

POTENTIAL APPLICATIONS
INTERFACED EXPERT SYSTEMS/LASER OPTICS TECHNOLOGY
As of: January 25, 1991

APPLICATION # 1: NASA Shuttle Close Out Photography

ORGANIZATIONS: LSOC, USBI, Martin Marietta

NASA CONTACT: Astrid Heard, PT-AST, 867-2780; Nancy Pope, TE-CID, 867-2090

USER CONTACT: John Seaman, LSO-157, 861-2396; Kevin Paule, LSO-201, 867-0726; Gene Cain, Analex, 867-5716

NEEDS: To provide for the storage and rapid retrieval of Shuttle close-out photography. Approximately 10,000 8" x 10" color photographs obtained per launch.

MEDIA: 8" x 10" color still photographs.

SOLUTION: Use an expert system front-end linked to laser optics devices for photo information classification and retrieval. Baseline still video technology.

STATUS: Under active cooperative agreement development.

* *

APPLICATION # 2: Press Site News Photo Support

ORGANIZATION: NASA-KSC Public Affairs

USER CONTACT: Bill Johnson, PA-PIB, 867-7819/2468; JoAnn Mattey, TGS, 867-7826

NEEDS: To provide rapid retrieval of KSC-related photographs for various world-wide news organizations. Approximately 20,000, 8" x 10" color and B & W photographs; and 3000, 4" x 5" positive color transparencies exist in the system.

MEDIA: 8" x 10" color and B&W still photographs; and 4" x 5" positive color transparencies.

SOLUTION: Use an expert system front-end linked to a analog laser optics player for photo information classification and retrieval.

STATUS: This application will be used for validation of

expert system/laser optical storage, search and retrieval of a large database of photographs. Four (4) College of Business MBA students have developed a photo classifier and photo retriever during the Fall 1990 semester. In addition, one (1) College of Engineering student is developing a related audio/visual tape library database during the Fall 1990 and Spring 1991 semesters.

* *

APPLICATION # 3: LSOC Engineering Data Access & Management System (EDAMS) Retrieval Systems

ORGANIZATION: LSOC

NASA CONTACT: TE

USER CONTACT: Hudson Haile, LSO-043, 861-2261

NEEDS: To reduce production time and risk associated with processing, launch, and recovering Space Shuttle vehicles. Timely, adequate, and accurate engineering data are frequently needed. The desire is to create an integrated, open architecture system using the existing installed base of Shuttle processing engineering data.

MEDIA: Drawings, schematics, test data, specifications, photos, tables, historical data, etc.

SOLUTION: Use an expert system front-end linked to various forms of laser optics for data retrieval.

STATUS: Databases for several segments under discussion. Digital technologies will improve applications potential.

* *

APPLICATION # 4: KSC Lightning Data Storage and Retrieval

ORGANIZATION: NASA-KSC

USER CONTACT: Bill Jafferis, DF-ESS-22, 867-4438

NEEDS: To store and retrieve lightning satellite, radar, and field mill data (approx. TBD images). Approx. 40,000 satellite images and 10,000 radar images exist. Very large quantities of field mill networked data from 34 KSC sites stored on magnetic tape. Data is not readily available for analysis.

MEDIA: Satellite and radar photographic and images 8" x 11" strip chart hard copy images.

SOLUTION: Use an expert system front-end linked to an analog laser optics player for image retrieval.

STATUS: Satellite, radar, and field mill data has been recorded on laser disc system. Resolution is a minor problem but retrieval using an expert system/database is feasible for up to 54,000 images.

* *

APPLICATION # 5: NASA Educator Resource Center Slide Retriever

ORGANIZATION: NASA-KSC

NASA CONTACT: Steve Dutczak, PA-EAB, 867-4444

USER CONTACT: Janet O'Sullivan, Omniplan, 867-4090

NEEDS: To provide for a retrieval system for 35 mm color slides. Slides are used by national and international teachers in their classrooms.

MEDIA: 35 mm color slides (approx. 550).

SOLUTION: Use an expert system front-end linked to a analog laser optics player for photo information retrieval.

STATUS: Several database systems are being developed by two (2) College of Engineering students during the Fall 1990 and Spring 1991 semesters. They include systems for teacher and resource documentation, and inventory and mail-out.

* *

APPLICATION # 6: Univ. of Florida Citrus Tree Census Project

ORGANIZATION: NASA-KSC/Univ. of Florida Institute of Food & Agricultural Sciences.

NASA CONTACT: Tom Hammond, PT-TPO-A, 867-3017

USER CONTACT: Dr. Carlos Blazquez, Univ. of Florida Citrus Data Center, Lake Alfred, FL (813) 956-1151

NEEDS: To establish a method of storage and retrieval for large quantities of aircraft data.

SOLUTION: Use an expert system front-end linked to an analog laser optics player for image retrieval.

STATUS: Discussion begun with Dr. Blazquez to understand requirements. Dr. Blazquez has visited UCF Intelligent Multimedia Applications Laboratory (IMAL) for demonstrations. Further discussion are required but unscheduled.

* *

APPLICATION # 7: NASA-KSC Facility Drawing Retrieval

ORGANIZATION: EG & G Engineering Records

NASA CONTACT: Dave Springer, 867-3035

USER CONTACT: TBD

NEEDS: Approximately TBD facility drawings are stored. Drawings presently stored on microfisch for later reproduction on hard copy. User is required to know drawing number for retrieval.

MEDIA: Microfisch drawings.

SOLUTION: Use an expert system front-end linked to an analog laser optics player for image retrieval.

STATUS: No action taken for this potential application.

* *

APPLICATION # 8: Payload Customer Integration

ORGANIZATION: NASA-KSC, CP-APO

NASA CONTACT: Robert Young, CP-APO, 867-3374

USER CONTACT: Beth Cerrato, CP-PSO-A, 867-3183; Shirley Green CP-APO, 867-3374

NEEDS: NASA and their contractor representatives need a method to assist in evaluating commercial space experiment KSC processing requirements.

MEDIA: Text, database, possibly motion and still imagery.

SOLUTION: Use and expert systems front-end linked to a text and image database.

STATUS: Three (3) College of Business MBA students have developed a prototype systems during the Fall 1990 semester. In addition, one (1) College of Engineering student is developing a payload assignment/tracking systems database during the Fall 1990 and Spring 1991 semesters.

* *

APPLICATION # 9: Bionetics Environmental Aircraft Image Search and Retrieval System

ORGANIZATION: Bionetics

NASA CONTACT: Dr. William Knott, MD-RES-L, 853-5142

USER CONTACT: Dr. C. Ross Hinkle, Bio-2, 853-3281

NEEDS: To establish a search and retrieval system for approximately TBD 10" x 12" aircraft photographs.

MEDIA: Aircraft photography.

SOLUTION: Use an expert system front-end linked to an analog laser optics player for image retrieval.

STATUS: No actions taken for this potential application.

* *

APPLICATION # 10: NASA Safety Reliability & Quality Control Photo Retrieval System

ORGANIZATION: NASA-KSC SR & QA

NASA CONTACT: Judy Anderson Kersey, 867-3163

USER CONTACT: TBD

NEEDS: Develop a method for storage, search, and retrieval for a variety of R&QA photographs.

MEDIA: Various sized photographs.

SOLUTION: Use an expert system front-end linked to a laser optics device for data retrieval.

STATUS: No action taken for this potential action.

* *

APPLICATION # 11: Shuttle Processing As-Run Shuttle Historical Data System

ORGANIZATION: NASA-KSC

NASA CONTACT: Dick Thornburg/Gene Sestile, TM-PCO-2, 867-7401/-3844

USER CONTACT: As above.

NEEDS: A system which would provide quick access to shuttle processing as-run historical data.

MEDIA: Hard copy graphical/scheduling data.

SOLUTION: Use an expert system front-end linked to various forms of laser optics for data retrieval.

STATUS: No action taken for this potential action.

* *

APPLICATION # 12: Safety, Fire, and Security Facility Training System

ORGANIZATION: Safety and Protective Services

NASA CONTACT: Jim Lansing, RQ-SS, 867-4802

USER CONTACT: TBD

NEEDS: Several organizations within safety and protective services have periodic requirements for "surrogate travel" training systems for facility familiarization.

MEDIA: Motion, still, computer generated graphics, and text.

SOLUTION: Use an expert system front-end linked to various forms of laser optics for data retrieval.

STATUS: No action taken for this potential action.

* *

APPLICATION # 13: Spaceport USA Interactive Exhibits

ORGANIZATION: NASA

NASA CONTACT: Ed Harrison, PA-VIC, 867-2363

USER CONTACT: TBD

NEEDS: There is a continual need for interactive exhibits for Spaceport USA visitors.

MEDIA: Computer interfaced laser disc, CD-ROM, DVI, etc.

SOLUTION: Use an expert system front-end linked to various forms of laser optics for data retrieval.

STATUS: No action taken for this potential action.

* *

APPLICATION # 14: Expert Maintenance Diagnostics/Multimedia

ORGANIZATION: General Dynamics Space Systems (GDSS)

NASA CONTACT: None

USER CONTACT: Rick Ort, GDSS, 853-2793

NEEDS: Various complex launch complex systems exist which require specialized experience for diagnostics during a period where experienced people are retiring. Multimedia ties to a knowledge-based system would be invaluable for the retrieval of schematics, still photographs, and motion sequences.

MEDIA: Still video, motion, and drawings.

SOLUTION: Use an expert system front-end linked to various forms of laser optics for data retrieval.

STATUS: Three (3) College of Business MBA students have developed a prototype diagnostics multimedia system during the Fall 1990 semester.

* *

APPLICATION # 15: Equipment Trouble Shooting Expert

ORGANIZATION: ITT Defense Systems

NASA CONTACT: None

USER CONTACT: Ken Shaw, ITT, 633-7753

NEEDS: Diagnostic trouble shooting systems are needed to verify equipment performance and acceptance testing.

MEDIA: Still video, motion, and drawings.

SOLUTION: Use an expert system front-end linked to various forms of laser optics for data retrieval.

STATUS: One (1) College of Business MBA student has developed a prototype diagnostics system during the Fall 1990 semester.

* *

APPLICATION # 16: Multimedia Selection Advisor

ORGANIZATION: UCF College of Business

NASA CONTACT: None

USER CONTACT: Dr. James Ragusa, UCF, 823-2915

NEEDS: Various organizations need methods of determining the best media to use in presenting a specific message. In addition, those interested in Executive Information Systems (EIS) need rapid access to a variety of presentation multimedia.

MEDIA: Varied

SOLUTION: Use an expert system front-end linked to various forms of laser optics for data retrieval.

STATUS: Three (3) College of Business MBA students have developed a prototype multimedia system during the Fall 1990 semester.

* *

APPLICATION # 17: Intelligent Computer Aided Training/ Instruction

ORGANIZATION: NASA, DOD, NSF, and others

NASA CONTACT: None

USER CONTACT: Dr. James Ragusa, UCF, 723-2915

NEEDS: There is an ever expanding need for one-on-one,

self-paced intelligent Computer Aided Training/ Instruction. Strong interest by military training organizations.

MEDIA: Varied

SOLUTION: Use an expert system front-end linked to various forms of laser optics for data retrieval.

STATUS: Two (2) College of Business MBA students have developed a prototype multimedia system during the Fall 1990 semester. Two (2) MBA students will continue this development during the Spring 1991 semester.

* *

APPLICATION # 18: Quality Control Training

ORGANIZATION: NASA and others

NASA CONTACT: None

USER CONTACT: Dr. James Ragusa, UCF, 823-2915

NEEDS: Need exists for all levels of interactive quality training from solder certification to total quality control.

MEDIA: Varied

SOLUTION: Use an expert system front-end linked to various forms of laser optics for data retrieval.

STATUS: No action taken for this potential action.

* *

APPLICATION # 19: Training Devices Costing Estimator

ORGANIZATION: U.S. Army (PM TRADE)

NASA CONTACT: None

USER CONTACT: Richard Insinger, U.S. Army (PM-TRADE), 380-4349

NEEDS: Organizations responsible for the development of training devices need accurate methods of determining device costs based on requirements, specifications, and historical development experiences.

MEDIA: Varied

SOLUTION: Use an expert system front-end linked to various forms of laser optics for data retrieval.

STATUS: Three (3) College of Business MBA students have developed a prototype system during the Fall 1990 semester.

* *

APPLICATION # 20: Business Ethics Advisor

ORGANIZATION: UCF and Arthur Anderson & Co

NASA CONTACT: None

USER CONTACT: Dr. James Ragusa, UCF, 823-2915

NEEDS: There is a need in our contemporary society for providing quality advice concerning ethics issues. Sources of this advice can be based on norms, laws, expectations, and policies.

MEDIA: Varied

SOLUTION: Use an expert system front-end linked to various forms of laser optics for data retrieval.

STATUS: Three (3) College of Business MBA students have developed a prototype system during the Fall 1990 semester. This work was supported by Arthur Anderson & Co.

* *

APPLICATION # 21: Customer Help Advisor

ORGANIZATION: TBD

NASA CONTACT: None

USER CONTACT: Dr. James Ragusa, UCF, 823-2915

NEEDS: Providing quality help and advice at a service decision point is needed in numerous organizations and situations.

MEDIA: Varied

SOLUTION: Use an expert system front-end linked to various forms of laser optics for data retrieval.

STATUS: No action taken for this potential action.